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FEDERAL SURFACE VEHICLE NOISE RESEARCH, DEVELOPMENT, AND DEMONSTRATION PROGRAMS: FY 73 - FY 75

Environmental Protection Agency
Washington, D. C.

March 1975

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Prepared by

Interagency Surface Vehicle Noise Research Panel

Program Element No.
1GB090

Project Office:
Noise Technology Staff
Office of Research & Development
U.S. Environmental Protection Agency
Washington, D.C. 20460

Prepared for

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1. SUMMARY

In partial fulfillment of its responsibility for coordinating Federal noise research, the Environmental Protection Agency has established an interagency Surface Vehicle Noise Research Panel. The Panel membership includes Federal representatives from the Department of Transportation, the Department of Commerce (National Bureau of Standards), the Department of Defense, the Department of Housing and Urban Development, and the Environmental Protection Agency. With the exception of HUD these agencies sponsor and conduct the vast majority of the surface vehicle noise research, development and demonstration (RD&D) activities in the Federal Government. Other Federal agencies known to be sponsoring surface vehicle noise research, are the U.S. Department of Agriculture and the National Science Foundation. In addition, this Panel has been charged with the responsibility for addressing the Federal research supporting land use policies.

The initial task of this panel was the preparation of a report on the Federal Government's surface vehicle noise RD&D and land use related research activities. This report, however, will only address the Federal surface vehicle RD&D activities as no Federal research programs reported were specifically identified with land use. The report reflects the views of the panel members as experts in the field and does not necessarily represent the policies or viewpoints of the agencies represented.

Table 1.1 is a summary of the major surface vehicle noise research programs being sponsored by the Federal Government. The total noise dedicated resources are shown to peak at $3,374,000 in FY 1974. However, it should be noted that the resource commitments for FY 1975 are known to be incomplete, and resources allocated to noise for research programs not dedicated to noise and for DOT in-house research are not included in any of the fiscal year data.

The DOT is the principal Federal agency sponsoring surface vehicle noise RD&D. These activities are primarily concerned with transportation systems and are associated with three major programs. They are Highway Noise Reduction, Urban Transportation System Noise Reduction, and Conventional Railroad and Intercity High Speed Systems. With emphasis being control of highway noise, the major efforts have concentrated on the control of heavy duty truck and bus noise. Future research efforts emphasize truck tire and engine mechanical and combustion noise.

Although the DOT resource allocations to reduce noise from urban transportation and conventional and high speed railway transportation

Table I.1 SUMMARY OF THE FEDERAL SURFACE VEHICLE NOISE R&D PROGRAMS

SPONSORING AGENCY	DESCRIPTIVE TITLE OF PROGRAM	FISCAL YEAR FUNDING ($1,000) PRIOR TO 1973	1973	1974 (est)	1975 (2)
DOT	Highway Noise Reduction	2,066	1,798	1,429	935
	Urban Transportation System Noise Reduction Program	(1)	356	577	(1)
	Conventional Railroad & Intercity High Speed Systems	(1)	(1)	150	200
	TOTAL DOT	2,066	2,154	2,156	1,135
DOD/ARMY	Conformance with Regulatory Requirements		215	270	
	Vehicle Signature Reduction	100	100	95	
	Noise Reduction Program for U.S. Army Construction Vehicles		369	300	160
	TOTAL DOD/ARMY	100	684	665	160
EPA	Interstate Motor Carriers		170		
	Interstate Rail Carriers		199		
	New Medium & Heavy Duty Trucks			178	
	TOTAL EPA		369	178	
USDA	Reduction of Vehicle (snowmobile) and Equipment Noise Levels			25	39
	The Use of Trees and Shrubs in Noise Abatement			20	
	Noise & Vibration of Off-Road Equipment		4	28	
	TOTAL USDA		4	73	39
NSF	Effects of Building and Other Boundaries on Motor Vehicle Noise			30	
	Noise and Vibration from Transportation Vehicles and Other Machinery			272	
	TOTAL NSF			302	
	TOTAL FEDERAL EFFORT	$2,166	$3,211	$3,374	$1,334

(1) Resources for inhouse research and noise portions of advanced transportation systems development are not included.
(2) FY 75 estimates are known to be incomplete.

systems are not specifically identifiable from within total development funding, significant noise research efforts are underway in these non-noise dedicated programs. The emphasis is in the development of future mass transportation systems. As such, noise is only one of many factors being considered and is often addressed as a design specification.

The DOD/Army has three RD&D programs concerned with surface vehicle noise control. They are the Conformance with Regulatory Requirements, Vehicle Signature Reduction Program, and the Noise Reduction Program for U.S. Army Construction Equipment. These programs are funded by the U.S. Army Tank Automotive Command (TACOM) and the U.S. Army Mobility Equipment Research and Development Center (MERDC) and address highway and off-highway military vehicles. The TACOM Conformance with Regulatory Requirements program is directed toward reducing interior and exterior noise levels of all tactical type military vehicles to meet military and commercial noise standards. The MERDC Noise Reduction Program for U.S. Army Construction Equipment was initiated as a result of the low noise exposure level requirements established by the Army Surgeon General and is concerned with the control of noise from both stationary and vehicular construction equipment. The TACOM Vehicle Signature Reduction program is concerned with reducing the noise signature detectability of military vehicles for combat purposes. Portions of this program are classified. Although no other DOD surface vehicle research programs were identified, there is evidence that other pertinent noise reduction programs are being sponsored by DOD, particularly by the Navy on watercraft. DOD plans to continue a similar effort during the fiscal year 1975-78 period.

The EPA identified three surface transportation research programs which were sponsored in FY 1973 and 1974 to support the Interstate Motor Carrier, Interstate Rail Carrier, and New Medium and Heavy Duty Trucks regulations. These studies generally involved the determination of the population impacted by the noise source to be regulated, best available noise control technology, costs for compliance with the proposed regulations, and measurement methods for enforcing the regulations.

The USDA sponsors surface vehicle noise research through the Forest Service and the Cooperative State Research Service. These programs are concerned with control of off-road vehicle noise and the use of trees and shrubs to abate noise. Only the off-road vehicle noise control research activities of the Forest Service are planned to continue into the future. The Cooperative State Research Service will continue to support noise research proposed by individual scientists and engineers based on scientific and engineering merits.

The NSF sponsors noise research based upon the merits of unsolicited

proposals. Currently, there are two NSF research grants specific to surface vehicle noise. They are entitled "The Effects of Building and Other Boundaries on Motor Vehicle Noise" and "Noise and Vibration from Transportation Vehicles and Other Machinery." A third grant entitled, "Basic and Applied Studies of Noise," has a minor portion of the study addressing sound generation by automotive tire designs.

The total Federally sponsored surface vehicle noise research activities can be classified into the following six research categories: highway vehicle noise control technology, railway vehicle noise control technology, off-highway vehicle noise control technology, noise system studies, noise regulations development and enforcement, and advanced systems development. For noise dedicated activities, the emphasis in the Federal efforts has been roughly equal between highway vehicle noise control technology development and noise regulations development and enforcement. In these areas the principal efforts have been control of heavy truck and bus noise. However, there is a significant Federal effort addressing noise generated by off-highway vehicles, principally those used in construction. Although not dedicated to noise, there are also major Federal programs (exclusively DOT) to develop advanced, future mass transportation systems which give significant attention to noise control and have potential applications to conventional systems. Total resource distributions for these categories are given in Table 4.1.

2. INTRODUCTION

2.1 BACKGROUND

Early in 1974 the Office of Research and Development of the Environmental Protection Agency invited Federal government agencies concerned with noise pollution research to designate representatives of their technical staff to serve as members on four noise research panels: aircraft, surface vehicles, machinery, and health effects. The requested agency representation on the panel is shown in Table 2.1.

Table 2.1 STRUCTURE OF EPA RESEARCH PANELS

Noise Research Panel	Current Agency Membership
Aircraft	NASA, DOT, DOD, HUD, DOC, EPA
Surface Vehicles*	DOT, HUD, DOD, DOC/NBS, EPA
Noise Effects	HEW, (NINDS, NIOSH, NIEHS), DOT NSF, HUD, NASA, DOD, DOL DOC/NBS, EPA
Machinery	HEW/NIOSH, DOL, DOI/Bureau of Mines, NSF, DOD. DOC/NBS, EPA

*This panel was also charged with the responsibility for the Federal research supporting land use policies.

These panels were convened to provide the means for interagency coordination of research in the four technical areas. In addition to exchange of information the functions of the panels in their respective areas are:

- Review and assessment of the current state of technology.
- Review and assessment of the status of research and technology development.

- Preparation of recommendations concerning ongoing research activities.

- Recommendation of noise research programs and projects, and methods for their accomplishments.

- Preparation of reports on the status and/or progress of on-going noise research activities.

- Receipt and review of pertinent scientific and programmatic advice from communicating with other standing bodies.

The names and addresses of the Surface Vehicle Noise Research Panel members are listed in Appendix A.

2.2 PURPOSE

Each of these panels of experts has met to charter its course of action as a consultative body, and it was agreed that each panel would generate a report on the Federal noise research, development, and demonstration (RD&D) activities and the noise research needs in the specific area of consideration by the panel. To prepare the report, the EPA requested each of the panel members to provide information on their agency's noise RD&D activities. With the request EPA offered an example of the type of information desired but indicated that the information could be provided in a form most convenient to the agency (i.e. their agency's project and program information forms or over-views). Appendix B contains a copy of the EPA example and the program and project information desired.

This report is the first to be prepared by the Surface Vehicle Noise Research Panel. Its purpose is to present a description of Federally supported RD&D which is directed toward control of noise problems attributable to surface vehicles or support of Federal land use policy development. This document will be used by the Environmental Protection Agency in preparing a report to satisfy Section 4(c)(3) of the Noise Control Act of 1972. EPA is required to report on the status and progress of Federal activities relating to noise research and noise control and the contribution of such activities to the Federal Government's overall efforts to control noise. The panel report is a digest and analysis of information provided by the Federal agencies involved in surface vehicle noise RD&D. The report reflects the collective opinions of the panel members and does not necessarily represent the policy or viewpoints of the respective agencies.

2.3 SCOPE

In the current Federal effort most surface vehicle noise RD&D on surface transportation systems is being sponsored by the Department of Transportation. Other agencies sponsoring research on surface vehicle noise are the Department of Defense/Army, the National Science Foundation, the Environmental Protection Agency, and the U.S. Department of Agriculture. There were no Federal research programs identified which were specifically concerned with land use policy development.

In presenting the current Federal activities, emphasis has been placed on the RD&D activities in FY 1973 and 1974. Previous efforts and future projections for major programs are also presented where such information was provided. Fiscal data reported is accurate as of July, 1974, but may not reflect the complete resources available for each program or project. This is principally because resources allocated to salaries, equipment, and other services for in-house studies have not been reported by all of the agencies. Because of FY 1974 carryover money, the FY 1974 resource allocations are best estimates in many cases. For FY 1975, not only are the resources identified estimates in most cases, but some detailed program and project planning is not complete. Therefore, the FY 1975 resource estimates are also incomplete. Although it is probably unavoidable to omit some related Federal activities, it is the consensus of the panel members that no major Federal research programs in the area of surface vehicle noise have been overlooked.

The program and project descriptions of the Federal surface vehicle noise RD&D are presented in Section 3 by agency. In Section 4 the current programs are briefly analyzed and grouped into the categories of specific surface vehicle noise control technology development, noise systems studies, research directly supporting regulations development and enforcement and advanced transportation systems development.

2.4 SURFACE VEHICLE NOISE SOURCES

Surface vehicles include mobile systems used in transportation, construction, defense, recreation, and agriculture. These systems can generally be classified according to three all inclusive noise source categories. They are highway vehicle noise, railway vehicle noise, and off-highway vehicle noise. The relative noise levels associated with these sources of surface noise are illustrated in Table 2.2. Noise emitted from these sources, however, is derived from the components of the source, the vehicle's subsources. Table 2.3 illustrates the contribution of the subsources to the total noise levels emitted by diesel trucks, motorcycles, and snowmobiles.

Table 2.2 COMPARISON OF TYPICAL NOISE LEVELS FOR SURFACE VEHICLES (1)

CATEGORY	Average Noise Levels (2) (dB(A) at 15.24 Meters (50'))
HIGHWAY VEHICLES	
Medium and Heavy Duty Trucks	84 (88)
Motorcycles (Highway)	82 (88)
Utility and Maintenance Vehicles	82 (88)
Highway Buses	82 (86)
Sports Cars	75 (86)
City and School Buses	73 (85)
Light Trucks and Pickups	72 (86)
Passengers Cars (Standard)	69 (84)
RAIL VEHICLES	
Locomotives	94
Passenger Trains	85
Rapid Transit	87
Trolley Cars (Old)	80
Trolley Cars (New)	66
OFF-HIGHWAY VEHICLES	
Recreational	
Motorcycles	85
Snowmobiles	85
Inboard Motorboats	80
Outboard Motorboats	80

(Continued)

Table 2.2 (Con't.)

CATEGORY	Average Noise Levels (2) (dB(A) at 15.25 Meters (50'))
Construction	
Trucks	88
Scraper	88
Dozer	87
Concrete Mixer	85
Paver	89

(1) The average noise levels reported in Table 2.2 were obtained from an unpublished EPA contractor report entitled "Rationale for the Identification of Major Noise Sources" Table A-1. The values were originally obtained from EPA document NTID 300.13, December 31, 1971, and HUD Departmental Circular 1390.2, August 1971.

(2) Values in parentheses are typical for maximum acceleration. All other values are normal cruising speeds. Variations of 5dB can be expected.

Table 2.3 SUBSOURCES OF NOISE FOR TYPICAL SURFACE VEHICLES

Subsource	Typical Noise Levels (dB(A) at 15.24 Meters (50')) Diesel (1) Trucks	Motorcycles (2)	Snowmobiles (2)
Engine Mechanical & Combustion	78	78	76
Exhaust	85	86	82
Air Intake	75	82	85
Cooling Fan	82	-	80
Tires	75 (95)	69	-
Track	-	-	72
Total	88 (96)	88	88

(1) Values in parentheses are for trucks operating above 35 mph, source of information: Close, W.H., DOT Truck Noise Reduction Program, Internal DOT Description Document.

(2) The noise levels indicated for these sources were obtained from EPA document NTID 300.13, December 31, 1971.

3. FEDERAL SURFACE VEHICLE NOISE RD&D PROGRAMS

3.1 DOT SURFACE TRANSPORTATION NOISE ABATEMENT PROGRAMS

There are three major DOT noise research programs. They are entitled the Highway Noise Reduction Program, the Urban Transportation Systems Noise Reduction Program, and the Conventional Railroad and Intercity High Speed Systems. The sub-program tasks, projects and fiscal data associated with these programs are listed in Tables 3.1, 3.2, and 3.3 respectively. The tables indicate that the major noise dedicated efforts are in highway noise reduction. Significant noise RD&D activities are identified in the other two programs but generally noise is only one of several considerations. Many of these latter activities are associated with the development of advanced, future mass transportation systems. Brief descriptions of these programs and their component projects are contained in the following sections.

3.1.1 Highway Noise Reduction Program

Since 1970 the Department of Transportation has been actively engaged in a multifaceted effort to reduce the impact of noise generated by heavy duty trucks and buses upon the community adjacent to the nation's public highways. The results of this program to date are numerous and further information is forthcoming. Pertinent reports developed under this program are available and reflect the degree of noise reduction achievable through the application of the best available technology considering cost of compliance.

Summary description documents (references 1,2) have been prepared which set the DOT program of truck noise reduction into perspective and delineate the plans for and accomplishments of the program realized as of late 1972. Since that time the program has developed according to the plan, but with some expansion of efforts.

Quiet Truck Program - An investment of approximately $1.25 million dollars has been made on three DOT contracts with the Freightliner Corporation, International Harvester Co., and the White Motor Co. to develop and demonstrate the lowest practical noise levels achievable on selected heavy duty diesel powered truck tractors.

Table 3.1 SUMMARY OF DOT HIGHWAY NOISE REDUCTION PROGRAM

Descriptive Title	Investigator (s)	Fiscal Year Funding ($1,000) Prior to 1973	1973	1974 (est.)	1975 (est.)*
Quiet Truck Program	Freightliner International Harvester Co. White Motor Co.	1,046	100	100	-
Exhaust/Intake Mufflers	Donaldson Co. Stemco Manufacturing Co.	75	28	-	-
Truck Noise Handbook	Cambridge Collaborative		15	25	-
Construction Equipment Mufflers	Vehicle Research Institute			50	
Engine Noise Support	Bureau of Mines/DOI		80	40	-
Truck/Bus Retrofit	General Motors PACCAR International Harvester Rohr Industries McDonnel-Douglas Co.		450	72	-
Basic Engine Noise Reduction	Not specified			245	245
In-Cab Noise Tests	In-House & National Bureau of Standards	-	-		-
Truck Tire Noise Study	National Bureau of Standards	468	100	100	200
Truck Tire Noise Basic Research	North Carolina University	119	-	150	250
Highway Noise Enforcement Training & Equipment	California Highway Patrol	-	450	70	-
Roadside Enforcement Sites	Not specified			100	50
BMCS Training/Equipping	Not specified				
NCHRP Project III (highway noise models)	Bolt, Baranek, & Newman	120	120	180	-

Table 3.1 (Cont'd)

Descriptive Title	Investigator (s)	Fiscal Year Funding ($1,000) Prior to 1973	1973	1974 (est.)	1975 (est.)*
Magnitude of Transportation Noise Generation and Abatement	Serendipity	++	-	-	-
Scale Modeling Highway Noise	Ling-Temco-Vought	79	-	-	-
Scale Modeling Urban Traffic Noise	Massachusetts Institute of Technology	-	112	-	
Development of Highway Noise Standards FPM-2	In-house	+	+	+	
FPM 90-2 Training Manual Course	Bolt, Baranek, & Newman	-	132	+	+
FHWA Highway Design Manual	Urban Systems	-	54	-	-
Construction Equipment Standards	California Division of Highways	57	90	80	80
Highway Barrier Effectiveness	California Division of Highways	43	7	-	-
Acoustic Material Applications	Bolt, Baranek, & Newman			115	110
Barrier Parametrics	In-house	+	+	50	+
Traffic Noise Study	State of Maryland	43	37	37	-
Community Noise Study	State of New Jersey	16	20	20	-
Passenger Car Tire Noise	In-House and State of Colorado	-	3	+	
	TOTALS	2,066	1,708	1,429	935

* FY 75 estimates known to be incomplete
\+ Primary in-house funds
++ Not dedicated to surface vehicle noise, noise resources not available

Table 3.2 SUMMARY OF DOT URBAN TRANSPORTATION SYSTEMS NOISE REDUCTION PROGRAM

Descriptive Title	Investigator(s)	Fiscal Year Funding ($1,000) Prior to 1973	1973	1974 (est.)	1975*
Transit Bus Noise Reduction Potential	MTA	-	26	-	-
Purchase Specifications - Transit Coaches	MITRE	-	-	22	-
TRANSBUS Program	Not specified	++	++	++	++
Personal Rapid Transit Program	Not specified	++	++	++	++
Dual Mode Program	Not specified		·	++	++
Rapid Transit Systems Noise Environment	In-House				
New York City Transit System Study	PINY			125	-
Chicago Transit Authority Study	University of Illinois			60	-
Other Transit Authority Study	Not specified			120	
Wheel/Rail Noise & Vibration Study	Bolt, Baranek, & Newman		184	-	
Elevated Structures Noise & Vibration	Cambridge Collaborative		146	-	
In Service Noise Abatement Test & Evaluation	Not specified		-	250	-
New System's Specifications - Capital Grants	Not specified	++	++	++	++
State-of-the-Art-Car	Not specified	++	++	++	++
Screech Loop - Pueblo Facility	In-house	+	+	++	++
TOTALS			356	577	

* FY 75 estimates known to be incomplete
\+ Primary in-house funds
++ Not dedicated to noise, noise resources not available

Table 3.3 SUMMARY OF DOT CONVENTIONAL RAILROAD AND INTERCITY HIGH SPEED SYSTEMS NOISE RELATED PROGRAMS

Descriptive Title	Fiscal Year Funding ($1,000) Prior to 1973	1973	1974 (est.)	1975*
Measurement of Railroad	+	+		
Joint DOT/AAR Railroad Noise Research	-	-	150	200
Linear Induction Motor Research Vehicle	++	++	++	++
Magnetical Levitated Research Vehicle	-	-	+	+
Tracked Air Cushion Research Vehicle	++	++	++	+
Prototype Tracked Air Cushion Vehicle	++	++	++	++
TOTALS			150	200

* FY 75 estimates known to be incomplete
\+ Primarily in-house funds
++ Not dedicated to noise, noise resources not available

In the general work statement (reference 3) for the "Quiet Truck Program" the contractors were obliged to establish their own contract target noise level limits for each of the two truck configurations to be evaluated. Listed below is a table of goals proposed by each of the contractors (which became part of the contracts) and results of the contract research to date.

Table 3.4 QUIET TRUCK PROGRAM NOISE CONTROL GOALS AND ACCOMPLISHMENTS

Contractor	Goals*	Accomplishments*
Freightliner	(1) 75-78dB(A)	72dB(A)
International	(1) 75-78dB(A)	77-78dB(A)
	(2) 78-80dB(A)	79-80dB(A)
White Motor Co.	(1) 75-78dB(A)	77dB(A)
	(2) 81-83dB(A)	79dB(A)

*Maximum sound level per SAE J366a test
(1) Enclosed engine version
(2) Unenclosed engine version

Two reports (references 4,5) of the many to emanate from this project have been completed. In anticipation of the demand for public information on these efforts, technical sessions at two professional society meetings were arranged in which the summary findings of the project could be conveyed to the public prior to completion of the detailed DOT project reports. Papers were presented at the Society of Automotive Engineers (SAE) National West Coast Meeting (references 6,7,8) in August of 1973, at Noise Con 73 (references 9,10,11,12,13) in October 1973, and at Inter-Noise 74 (reference 14).

A number of detailed reports are presently in preparation to delineate the specific tests, design considerations, operational implications, and costs associated with the development of these quieted trucks. In addition, nine trucks, as indicated below, are currently in field service evaluation with line haul carriers to proof test the noise reduction concepts and verify the estimates of operational and cost implications.

Table 3.5 FIELD SERVICE EVALUATION BY LINE HAUL CARRIERS

Contractor	Number of Trucks	Operator
Freightliner	1	Mid American Lines
International	4	Ryder Truck Lines
White	1	Overnite Transport
White	3	Carolina Lines

Following approximately one year of service evaluation on each truck, final reports will be prepared and published to document the experience gained in line haul service of the quieted trucks as compared to comparable production trucks. Completion of the service evaluation will occur in July of 1974 for the first trucks and February 1975 for the last trucks introduced into service.

As a further adjunct to this program, the International Harvester contract has been expanded to encompass fleet testing of 24 different installations of "demand" fan drives. This will provide an extensive evaluation of the duty cycle of such fan-noise obviation and energy saving installations in service across the country. Reference 15 is a listing of the 23 installations currently under test.

Exhaust/Intake Muffler - Rather than rely solely on long term future solutions to the problems of truck noise, the DOT also undertook a series of closely related efforts to produce information upon which near term decisions could be based: (1) for new product standards; and (2) for retrofitability of noise reduction components to current fleets of trucks and transit coaches powered by the popular diesel engines.

The first contracts in this effort were intake and exhaust muffler performance evaluation tasks. The Donaldson Co. and the Stemco Manufacturing Co. were awarded parallel contracts to acquire and evaluate available intake air cleaners and mufflers for acoustic performance and to document cost and ancillary performance effects (pressure restriction,

etc.) The results of these two contracts are contained in final DOT reports (references 16,17). The results of the Donaldson study are also reported in a professional society report (reference 18). These tests validated the contention that an ample supply of commercial mufflers exists to significantly reduce intake and exhaust noise of production trucks. Table 3.6 illustrates the general capabilities of better mufflers being used on the most popular diesel engines. The same reports place intake noise and component cost versus performance into a new, clearer perspective.

Table 3.6 SOUND LEVELS OF BASIC EXHAUST SYSTEMS

Type System	Sound Level dB(A)(1)				
	NHC-250	NTC-350	6-71	8V-71	ENDT-675
Unmuffled	95	93	105	104	82
SVVTP	96.0	79.0	78.0	82.0	72.5
SVVTP + Wye (3)				80.0	
CVVTP				80.0	
SHVTP	75.0	79.5	78.0	81.0	70.5
DHVTP				81.5	
SHHTP	81.0	80.0	81.0		(2)
DHHTP				74.0	

(1) "A" weighted sound level reference 20 micronewtons per square meter. Measured at 15.24 meters (50').
(2) All mufflers tested exceeded back pressure limits.
(3) Wye muffler is used to join the two exhaust banks into a single system.
Exhaust System Code "XY ABC"
XY donoted muffler configuration: S single, D dual, V vertically mounted, H horizontal.
ABC donotes tail pipe system, V vertical, H horizontal.

Truck Noise Handbook - A task order contract with Cambridge Collaborative is being used to write a popularized version of the results of the two muffler contracts, the cooling system results from the "quieted" trucks, and general noise testing procedures into one comprehensive handbook for field use in implementing truck noise reduction. This effort is nearing the publication stage and a final handbook was scheduled for completion July 1974.

Construction Equipment Mufflers - A contract is presently being

negotiated with the Vehicle Research Institute (VRI) of the SAE to study and evaluate the applicability of the muffler and cooling system technology to construction equipment. Recommendations for dissemination to that industry will be made by VRI.

Engine Noise Support - An interagency agreement with the Bureau of Mines, Bartlesville Energy Research Center has produced a variety of information on the performance and air emissions of similar diesel engines with specific attention paid to effects of noise reduction components. Bartlesville personnel also participated in program planning for future diesel engine noise research.

Truck/Bus Retrofits - Most directly applicable to the regulatory process for new trucks is the series of five contracts recently awarded by the DOT to determine the degree of noise reduction possible through optimum selection of air cleaner/inlet mufflers, exhaust mufflers, and cooling system components. Contracts have been written with: General Motors Truck and Coach Division, PACCAR (parent corporation including Kenworth and Peterbilt), International Harvester, Rohr Industries (Flexible Coach), and McDonnel-Douglas Co. (with White Motor Co. as subcontractor). Ten trucks and two transit coaches will be evaluated and quieted through detailed studies. Ten other trucks will be evaluated as to the applicability of the hardware developed for the primary study vehicles. $500,000 of Federal funds are being augmented by $325,000 of industry cost sharing to perform this effort. Final reports are scheduled to be finished by mid calendar year 1975. On the basis of the information (reference 19) supplied to prospective bidders regarding the tasks to be performed in this truck and bus retrofit study, it is evident that DOT is seeking technology answers to the problems of typical vehicles but, in addition, is also seeking definitive studies of vehicles known to possess atypical noise problems. Accordingly, some of the results expected from this effort will quite possibly delineate a number of truck models which simply cannot be expected to be made as quiet as the "typical" truck. From this information, the impact of regulatory decisions should be much clearer for both the "typical" heavy duty vehicle, and vehicles which may have to be prematurely retired due to excessive costs to quiet.

To facilitate dissemination of information resulting from these efforts, the contractors are obligated to prepare service bulletins pertinent to the test vehicles and to distribute these notifications to all owners of record of the affected vehicles. DOT anticipates that these service bulletins will establish a precedent in the industry which will be followed by broad voluntary dissemination of noise information by all manufacturers to their customers.

Basic Engine Noise Reduction - For even longer term considerations,

DOT has initiated procurement activities to study the options available in reducing inherent diesel engine noise through engine design modifications. The efforts of the Bureau of Mines and the so called "Quiet Trucks" have provided the initial information for this effort as well as options to encapsulate engines for noise reduction purposes. This study will delve more deeply into the basic mechanisms of noise generation and radiation by diesel engines and the potential abatement techniques applicable to present and future engine designs. This will be a three year laboratory and field test program which is expected to cost a half million dollars. From this effort, it is anticipated that engine design parameters will be developed which will provide a full option to the encapsulation techniques developed in the previous DOT research and/or provide means to lower engine noise beyond that achieved solely by engine shields and encapsulation if needed.

In-Cab Noise Tests - The DOT has exercised its safety responsibilities in various areas affecting heavy duty trucks and buses. One of these areas of responsibility includes regulating the noise exposure of drivers of commercial vehicles. In keeping with the authorization and direction of the Congress as expressed in the Noise Control Act of 1972, DOT has carried out its program of operator noise exposure protection through research and development to the regulation stage.

In October of 1970 an advanced notice of proposed rule making by the DOT Bureau of Motor Carrier Safety (BMCS) regarding sound levels in commerical vehicle cabs was issued. A field measurement and analysis effort was undertaken the following summer of 1971 to ascertain interior sound levels and to develop simplified test procedures. Through the cooperation of Regular Common Carrier Conference and the American Trucking Associations, sixteen trucks were made available for testing. (Due to interest in community noise on the part of the truckers and the DOT, the exterior noise levels were measured as well as the interior noise levels of the test trucks).

Interior and exterior noise level data were acquired by the National Bureau of Standards (NBS) for DOT for a variety of truck operating procedures which included: stationary low idle, stationary engine acceleration, stationary high idle (governed rpm), SAE J366a acceleration, SAE J366a deceleration, and SAE J366a engine brake deceleration (reference 20).

An analysis of the significance of the various tests and a recommended enforcement procedure for interior noise level has been reported (reference 21). A methodology to relate the simplified procedure to driver exposure and the hearing conservation criterion of the Occupational Safety and Health Act was proposed. Sample measurements of typical over-the-road driver sound level exposure were also reported.

Subsequently a Notice of Proposed Rule Making (reference 22) was issued by the BMCS on January 4, 1973, based upon the results of the above research, to limit interior truck noise with specific performance standards and compliance testing specified. In-house studies documented by BMCS (reference 23) and independent studies by the Motor Vehicle Manufacturers Association (MVMA) confirmed the validity of the compliance testing procedure relative to the desired exposure control. On November 8, 1973, the Director of the Bureau of Motor Carrier Safety issued new Part 393.94 establishing maximum interior sound level limits for newly-manufactured and in-service trucks and buses operated in interstate commerce.

The BMCS has also undertaken research to relate noise and other commerical vehicle environmental factors (vibration, heat, etc.) to driver fatigue, etc. The results of this effort have been reported (reference 24).

Truck Tire Noise Study - The very first item of surface transportation noise research undertaken by the DOT Office of Noise Abatement was a comprehensive study of tire noise. DOT undertook this program in 1969 as the first phase of its highway vehicle noise research because it had been determined that: (1) tire noise is speed dependent, thus it is typically the dominant high speed truck noise source; (2) Interstate highway construction progress has generated a continuing increase in average truck speed; (3) tire noise to some degree is dependent upon road surface and; (4) the majority of the remaining Interstate system to be constructed is in urban areas. The course of action taken was to enter into an interagency agreement with the Office of Vehicle Systems Research (OVSR) of the National Bureau of Standards to conduct pilot studies of auto tire noise (due to their heavy involvement with auto tire safety standards for DOT).

From this pilot effort and information obtained from General Motors, it was determined that meaningful data could be acquired using coast-by test procedures. With this base of understanding and experience, DOT and NBS prepared a test plan for a parametric examination of truck tire noise through field testing.

During the performance of this study, the OVSR was transferred enmasse from NBS to DOT and the tire noise program execution was redirected by DOT to the Applied Acoustics Section of NBS. No significant disruption of the program was experienced by this transition which was planned in anticipation of the organizational change. An excellent test site was made available at Wallops Island, Virginia, by the National Aeronautics and Space Administration. Test tires were provided gratis by several trucking companies through the American Trucking Associations. NBS acquired the necessary acoustic equipment, became familiar with its operation and conducted initial tests at Wallops Island in 1970. Test-

ing during the summers of 1970 and 1971 resulted in the acquisition of the largest known data base of truck tire noise. The first (references 25,26) of a series of reports based upon these data document the variation of truck tire noise with: tire tread type, vehicle speed, vehicle loading, tire wear, and to a limited degree road surface, number of tires, and effects of water on the road surface.

Currently in preparation are several additional reports derived from this data base covering the subjects of: regulatory and use implications, spectral and directional characteristics of truck tire noise, and implications of the data in regards to the mechanisms of tire noise generation. In addition, evaluation tests of candidate tires for standard military procurement were evaluated and were reported (reference 27).

A substantial number of professional society papers have been written by DOT and NBS on the subject of tire noise. (See references 28,29,30,31,32 for examples). The findings of this program to date served as input data for the EPA proposed Interstate Motor Carrier Noise Regulations (reference 33). It is anticipated that the findings will further serve as the basis for tire noise regulations to be written by the California Highway Patrol (CHP) in accordance with Sections 27502 and 27503 of the California Motor Vehicle Code (reference 34) and possible future tire noise regulations to be written by EPA.

Truck Tire Noise Basic Research - While the above tire noise efforts have quantified the important factors pertaining to selective use of tires, road surface implications and regulatory implications, the matter of specific tire noise generation mechanism would remain unanswered unless more specific research into this point was successfully conducted. Accordingly DOT has awarded a four year $270,000 grant to the North Carolina State University (NCSU) to undertake a theoretical and experimental study of tire noise generation. Through the first two years of this grant, tire vibration (as opposed to air pumping or other turbulent aerodynamic phenomena) has been identified as a major noise source mechanism in many truck tires. Subsequent tasks have been planned which are necessary for the design of quiet tires. These tasks are: isolation of tire vibration and sound sources through coherence function analysis of tire sound, vibration, and road surface roughness signals; road surface roughness measurement and modeling; and tire analytical vibration and noise models. A status report (reference 35) through August 1973 is available from NCSU.

Highway Noise Enforcement Training and Equipment - In the various aspects of the DOT program of truck noise reduction, numerous procedures of sound measurement and data presentation have been employed. The DOT has elected to use one common base of testing throughout this program

to ensure complete communications with the various participants and to ensure comparability of results. This common base has been the Society of Automotive Engineers Recommended Practice J366a or the latest version, J366b (reference 36) revised for editorial reasons. As illustrated in reference 20, DOT is very much attuned to the need to constantly review the adequacy of present testing techniques. The sensitivity of J366a relative to vehicle operation and/or microphone location was investigated and reported, noting that nowhere in the data were levels greater than J366a plus 3dB recorded at microphone locations other than that prescribed by J366a. The average difference in levels recorded 4.57 meters (15') to either side of the SAE microphone location was 0. The average difference in levels recorded 9.14 meters (30') to either side of the SAE microphone location was 0 to 0.5dB lower than at the SAE microphone location. The ranges of data were also small. A concluding statement, therefore, was made relative to J366a that: "This data serves to substantiate the validity of the SAE test procedure as a measure of maximum vehicle noise". Subsequent to that study in 1971 no data has been generated which would change the conclusions as to validity of J366 within a nominal $\pm$2dB tolerance. Higher test speeds would be detrimental to the process of reliably determining maximum truck noise (exclusive of tire noise).

As noted above, DOT is presently preparing a report on tire noise regulatory implications which will endeavor to provide supporting information for California standards to be developed on truck and automobile tire noise. In this effort leading up to the preparation of this report, DOT has concluded that tires need to be regulated in a totally separate fashion from trucks. DOT further concludes that with the exception of substituting "fast meter response" for the "slow meter response", the procedures and concepts of SAE J57 (reference 37) testing are adequate for truck tire noise rating.

In accordance with scientifically sound and practical approaches which exist for the specification and enforcement of motor vehicle noise control measures, DOT undertook the sponsorship of a training program for state and local officials concerned with this problem. In May and June of 1973, the California Highway Patrol (CHP) conducted six, four day courses to convey the background and experience gained by the CHP in developing and adopting legislation for the control of motor vehicle noise and in developing and enforcing specific new product and in-service vehicle noise regulations. The DOT also offered to make available basic instrumentation for the states to use in such enforcement programs which the states would undertake following completion of the DOT/CHP courses.

A total of 212 state and local officials attended the training courses at the Sacramento, California Academy of the CHP. A few representatives of the Environmental Protection Agency also attended, as did other DOT officials and a few industry officials.

The course material and the audio/visual training aids provided each attendee are contained in references 38 through 41. The object of the program was multifold, however, one primary objective was to determine if a well structured program, conducted by personnel possessing extensive background and experience could effectively convey the essence of vehicle noise enforcement techniques to a generally uninformed group of state and local officials, upon whom responsibility for such enforcement would possibly be placed in the near future. As the final report (reference 42) indicates, the program was an overwhelming success. The examination scores were raised from an average of 64.5% at entrance to 91.3% upon completion of the course. This report has been edited to preserve anonimity of the attendees thus permitting public disclosure of the program results.

Roadside Enforcement Sites - Further, in regards to measurement methodology, the DOT is initiating a program of roadside site categorization which will involve the measurement of control vehicles and traffic at a number of representative roadside enforcement locations to categorize the acoustic effects of such sites as are typically found adjacent to the nations highways and streets. Measurements during the summer of 1974 will provide pertinent data for this activity leading to the development of initial compliance regulations to be written by the DOT under authority of Section 18 of the Noise Control Act. This activity will, in all probability, be an on-going, low level, in-house effort to continually upgrade enforcement techniques, thus permitting enforcement measurements in more restricted spaces and accounting for other factors which at present would rule out sites for measurement purposes.

BMCS Training/Equipping - In fiscal year 1975, in-house and contractor efforts will provide expanded training of Bureau of Motor Carrier Safety (MBCS) inspectors for enforcement of the In-Cab Noise Regulation and Interstate Motor Carrier Noise Regulation. In addition, equipment to supplement that presently available for BMCS inspectors will be provided.

National Cooperative Highway Research Program (NCHRP) Project III - Dating back to fiscal year 1970 the DOT Federal Highway Administration (FHWA) has supported the NCHRP Project III for the development of information pertaining to highway noise and its associated problems. This is a jointly funded effort with the Association of State Highway Officials through the Highway Research Board and has, to date, produced three pertinent reports, NCHRP Reports 78, 117, and 144. Each report addresses the proposition of highway noise generation and provides information for the transportation and urban planner to perform his function appropriately in light of these predicted noise levels and community reactions. Other activities within the DOT have addressed this problem and have resulted in the development of highway noise prediction models. Under contract to the Office of the Secretary of Transportation in 1970, Serendipity Incorporated developed a sophisticated highway noise model which took

into account many factors as specific inputs which have been averaged in the succeeding NCHRP models. Reference 43 is the highway noise volume of the series of reports resulting from this study of the magnitude of the transportation noise problem. References 44, 45 and 46 document the computer program as refined and used by DOT Transportation Systems Center (TSC) and the short approximate method developed in-house at DOT/TSC. On-going effort has been directed towards updating these models and providing programs for different computers to accept either the NCHRP 117 model (computerization performed by the Michigan State Highway Department) or the DOT-Transportation System Center Model.

Scale Modeling Highway and Urban Traffic Noise - In many circumstances the topography is of such a complex nature as to invalidate the generalized assumptions used in computer modeling, hence, the use of small scale physical models has been applied on two DOT contracts. In 1969 a contract was written with Ling-Temco-Vought (LTV) to study the scale modeling problem of complex highway interchanges and to develop the sound source and measurement methodology to permit reliable small scale modeling. Corporate organizational problems resulted in the transfer of numerous key personnel away from the project, consequently, adequate final reports have not been prepared documenting this study. Subsequently, the Massachusetts Institute of Technology (MIT) has had a DOT grant to study scale modeling of urban traffic situations. Final reports are in preparation (should be available before the end of calendar year 1974) documenting the results of this study of traffic flow in simulated urban canyons.

Development of Highway Noise Standards PPM 90-2 - Section 136(b) of the 1970 Federal Aid to Highway Act specified that the DOT/FHWA promulgate by July 1, 1972, standards for highway noise levels, compatible with different land uses. Accordingly on April 26, 1972, the DOT Federal Highway Administration issued an advanced copy of its Policy and Procedures Memorandum PPM 90-2 entitled Interim Noise Standards Procedures for Implementing 109 (i) of Title 23 United States Code. This was updated in February 8, 1973, by final version PPM 90-2 entitled Noise Standards and Procedures (reference 47). The development of these standards was performed primarily in-house with the assistance of consultants in the employ of the DOT and under the auspices of the Association of State Highway officials.

PPM 90-2 Training Manual and Course - To assist in the understanding and implementation of PPM 90-2 the FHWA made provisions for preparing a one-week training course in the fundamentals and abatement of highway traffic noise. This course was prepared under contract by Bolt, Beranek and Newman (BBN) and initial courses were given under the leadership of BBN. Subsequently the same course is being made available through the Federal Highway Administration Regional Structure and is being conducted in-house by FHWA employees with the assistance of a few consultants.

A manual (reference 48) has been prepared that serves as a textbook for training courses.

The Highway Noise Standards and the training course are directed to those location, site, and design aspects of highway construction which are pertinent to the control of vehicular noise as it exists on today's highways. The computer programs mentioned above are based on empirical measurements on today's highways of today's vehicular noise levels, but adjustments to reflect vehicular noise control can be made in these programs.

FHWA Highway Design Manual and Construction Equipment Standards - Other activities include the preparation of design manuals for the construction of highway roadside barriers, and the exploratory research by the state of California Division of Highways regarding the establishment of feasible noise levels for construction and maintenance equipment utilized for highway construction.

Highway Barriers: Effectiveness, Acoustic Materials, Parametrics - A variety of Federal Highway Contracts and state research projects under the Highway Trust Fund allocation for Highway Planning and Research are, and have been, underway relating to design features of highways to abate existing highway noise. The state of California has completed a project relating to traffic noise near highways and the effects of design and environmental variables, including the development and demonstration of highway barriers near impacted residential areas. A contract has been let by the DOT/FHWA with BBN to explore the ramifications of using sound absorbing material on existing highway noise barriers and within tunnels. In addition, the DOT/TSC under the DOT, Office of the Secretary has conducted in-house theoretical studies and is preparing a field measurement program to evaluate the effectiveness of highway barriers relative to the line source of noise generated by a stream of heavy flowing traffic.

Traffic and Community Noise Studies - The state of Maryland has undertaken a project relating to highway design and abatement of traffic noise and the state of New Jersey has undertaken a program of community noise measurements.

Passenger Car Tire Noise - Other activities involving the Western Region Federal Highway Administration field force and the state of Colorado pertain to the noise generated by passenger car tires on various road surfaces. The design implications of tire/roadway interaction have been discussed above in the truck noise reduction program. While the problem is somewhat different, the results of the truck and passenger car tire research have been carefully coordinated and integrated insofar as the implications of highway surfacing are concerned from the standpoint of safety and noise.

3.1.2 Urban Transportation Systems Noise Reduction Program

Transit Bus Noise Reduction Potential - Within the broad area of mass transportation vehicles and systems development, numerous activities are underway relating to advancing the state-of-the-art of noise control. As mentioned previously, two transit coaches are included within the DOT Truck/Bus Retrofits programs and, in addition, a demonstration project by the Washington Metropolitan Area Transit Authority (WMATA) completed in 1972 demonstrated that significant noise reduction could be achieved in current "new look" transit coaches by the application of noise control engineering. The WMATA "quick and dirty" demonstration program illustrated the need to work on engine, exhaust, intake, and cooling system aspects of coaches to achieve noise reduction. The demonstration did not include the development of practical hardware to achieve these reductions as will be the case in the project presently underway.

Purchase Specifications: Transit Coaches - Currently underway is a low level effort by MITRE Corporation to more closely examine the test procedures and specification for community and passenger noise levels associated with transit coaches. The DOT Urban Mass Transportation Administration (UMTA) provides capital grants covering some 80% of all transit coach purchases. This contract with MITRE Corporation is being conducted in conjunction with the Society of Automotive Engineers Bus Noise Subcommittee.

TRANSBUS Program - Looking further to the future, the DOT is presently developing technology for future transit coaches in the forty foot urban design category. Three parallel contracts have been awarded for the development and demonstration of such coaches. Included within the design goals and specifications are very progressive interior and exterior noise level specifications. This program is presently in the acceptance test and evaluation phase of the demonstrator transit coaches produced by three suppliers: Rohr, Inc., General Motors Truck and Coach, and AM General Corporation. The portion of the twenty-three million dollar total effort which is devoted to noise control is not known since noise is but one of many integrated specifications for the project. However, the attainment of the seventy-five dBA exterior maximum noise goal will do much to forward the state-of-the-art and is considered by the DOT as a significant activity in the noise abatement area.

Personal Rapid Transit (PRT) Program - Other systems development and exploratory efforts in the area of personal rapid transit systems (PRT's) also include noise related activities as a part of the advanced work necessary to determine the applicability of such systems for future urban transportation needs. Contracts with Uniflow and Pullman Standard,

for example, include noise oriented activities related to rail personal rapid transit design concepts. Some of the findings of these systems study contracts may be pertinent to more conventional tracked rapid transit vehicles and to future design specifications for systems implementation. Estimates as to the specific cost of the noise related portions of these contracts are not provided since the segregation of noise from other design and evaluation tasks cannot be readily performed.

Dual Mode Program - Another activity is the so called dual mode technology development within the mass transit area. A variety of activities exploring the feasibility of integrating various modes of transportation to relieve the dependence upon automobiles includes, among other things, environmental compatibility; hence, a low level of in-house consultation and contractor effort in the noise area is included to assure noise compatibility of such systems.

Rapid Transit Systems Noise - In the area of rail rapid transit a concerted effort has been mounted to address the problems of noise in the community and the noise environment of riders and customers waiting in stations. In FY 1972 and 1973, measurement methodologies were developed to characterize the noise environment of rapid rail transit systems. The Massachusetts Bay Transportation Authority (MBTA) Lines were used as subjects for measurement and exploratory study. A final report is in preparation describing the noise climate of the MBTA. Subsequently, grants have been provided the New York Polytechnic Institute and the University of Illinois to study the New York City Transit Authority (NYCTA) and Chicago Transit Authority (CTA) properties respectively (along the lines of the study previously conducted by TSC/DOT of the MBTA). Request for proposals have been issued for similar studies of the Cleveland, Philadelphia, and San Francisco rapid transit systems.

Wheel/Rail and Elevated Structures Noise and Vibration - Contracts have been let for studies of (1) the development of wheel/rail noise and vibration control technology and (2) the development of track and elevated structure noise and vibration control technology with Bolt, Beranek and Newman and Cambridge Collaborative, respectively.

In-Service Noise Abatement Test and Evaluation - In 1974, the in-service test and evaluation of state-of-the-art noise control techniques will be conducted including: resilient wheels in Chicago, station acoustical treatment in Philadelphia, resilient fasteners in New York, and barriers in San Francisco. The in-service test and evaluation program has as its overall objectives the definition of cost and performance data of the various techniques as well as the evaluation of each technique considering safety, maintainability, etc., for application in future corrective programs and new systems designs.

Future plans call for the development and demonstration of applications of known technology as well as heretofore unproven technology in one or more transit authorities. The producers of these efforts will feed back through the cost and abatement documentation similar to that mentioned previously for the MBTA, NYCTA, and the CTA studies. Thus an integrated time phased program is well underway for the assessment of noise impact of existing rapid rail transit systems, and the means are at hand to begin to identify and resolve environmental incompatibilities.

New Systems Specifications: Capital Grants - In addition to the research and demonstration program activities, very important improvements and advancements are being made as a result of progressive systems specifications being drawn for new transit systems which are being developed with massive federal support. Examples include the Bay Area Rapid Transit District, the Washington Metro Systems, the Baltimore Transit System, and Atlanta Rapid Transit System. Such specifications, developed by the system consultants and approved by the DOT, exhibit incremental noise improvements with time. Estimates of the costs of such specifications cannot be provided, however, the noise reduction contributions of such system specifications will be significant.

Other programs such as the State-of-the-Art Car and the development of a screech loop at the Pueblo High Speed Test Center will add to the body of information permitting continuous improvement in rapid transit noise control.

3.1.3 Conventional Railroad and High Speed Ground Inter-City Transportation Noise Related Programs

Measurement of Railroad Noise - Prior to the passage of the Noise Control Act of 1972, conventional railroad noise complaints ranked relatively low on the list of priorities in the DOT (as measured by the frequency or number of community complaints and/or legal actions taken). The conventional rail network is contracting rather than expanding, and much of the land use adjacent to conventional rail lines has long been established and has acclimated to the noise of conventional railroads. Due to the desire of railroads to have uniformity of control and in reaction to a growing body of regulatory attempts by cities and states, the railroads lobbied for inclusion of Section 17 in the Noise Control Act of 1972 which requires the EPA to establish standards for noise emission of railroad equipment and facilities and for the DOT to write compliance regulations. Accordingly, the DOT undertook an accelerated program of in-house measurements of railroad noise to explore the magnitude of the problem and the means by which measurements and/or enforcement procedures could be developed. A number of measurements in the field were made of conventional and high speed trains between

Washington and New York and New York and Boston which encompass conventional freight, conventional passenger, Metroline and Turbo Train. One report (reference 49) has been published and an article (reference 50) based upon the data was published in "Sound and Vibration." In addition, an exploratory research program utilizing a load cell facility was undertaken to acquire baseline information on locomotive noise as a function of throttle position and fan operating cycle. Measurements of property line and specific source noise emissions were made during a one-week period in the Argentine yards of the Atchison, Topeka, and Santa Fe Railroad in Kansas City. Extensive data were acquired reflecting the property line noise levels as a function of noise source and operating mode. These data were acquired in a cooperative venture to support the EPA standards setting responsibility under Section 17 of the Noise Control Act and will be published shortly (reference 51).

Joint DOT/Association of American Railroads (AAR) Noise Research - Currently underway is a railroad noise research program in cooperation with the Association of American Railroads. This program will investigate locomotive noise characteristics under various operating modes with the prime objective being the development of simple, but effective, locomotive noise tests techniques. Also to be studied in this program is the effect of multiple locomotive units and propagation across adjacent terrain in order to allow efficient and equitable enforcement of EPA noise standards. Finally within the program, the demonstration of the effectiveness of retarder noise barriers is planned.

The above railroad noise research program will be initiated in FY 1974 and will carry through FY 1975 and portions of FY 1976. From this study it is expected that simple and reliable test techniques for evaluating railroad/locomotive noise, identification of individual sources of locomotive noise, identification of site variables pertinent to the measurement of locomotive/rail car noise, and demonstration of railroad retarder barriers to abate the excessive noise of these facilities will be accomplished. Cooperation on the part of the nation's railroads is anticipated through the gratis supply of equipment and operating personnel. From this base of information more specific actions in the future can be taken to identify the need to reduce railroad noise further and the means by which such reductions, if required, can be made.

High Speed Inter-City Dedicated Guideway Transportation Systems - Also within the DOT program of exploratory research and demonstration are activities associated with high speed intercity dedicated guideway type of transportation systems. Within these engineering demonstration efforts are a number of noise specifications and specific noise abatement tasks. For example, the Linear Induction Motor Research Vehicle, which is a steel wheel rail/linear induction motor propelled test vehicle operating at the Pueblo High-Speed Test Site, is being subjected to evaluation of noise

sources with emphasis on rail wheel noise and if feasible, exploration of linear induction motor and reaction rail noise generation. In conjunction with the Federal Republic of Germany and their high-speed ground research program, DOT anticipates acquiring data from tests of German magnetically levitated vehicles centering on the evaluation of aerodynamically generated noise of high speed vehicles. Engineering development programs of prototype tracked air cushion vehicle (PTACV) will provide additional information on the noise generation of air movers for such vehicle, cushions, and once again linear induction motor components. Noise specifications previously set for the PTACV have been factored into the design. Evaluation and, if necessary, corrective measures in future years will reveal significant findings regarding the peculiar apparatus of such high-speed ground transportation vehicles.

3.2 DOD SURFACE VEHICLE NOISE CONTROL PROGRAMS

The surface vehicle noise research programs identified within the DOD are those sponsored by the U.S. Army Tank Automotive Command (TACOM) and the U.S. Army Mobility Equipment Research and Development Center (MERDC). The TACOM Noise Control Program is divided into two program areas: Conformance with Regulatory Requirements and Vehicle Signature Reduction. Both are funded by the Army Materiel Command under the Tank and Automotive Technology Effort and are classified within the DOD as Exploratory Development Projects. The MERDC program is entitled "Noise Reduction Program for U.S. Army Construction Equipment" and includes mobile and stationary construction equipment. However, this report will only describe the portion of the program concerned with construction vehicles. The stationary construction equipment considered in the MERDC Program is addressed in the Federal Machinery Noise Panel Report entitled "Federal Machinery Noise Research, Development, and Demonstration Programs: FY73-FY75." Copies of this report are available from EPA. The projects associated with these programs are listed in Tables 3.7, 3.8, and 3.9. The substance of the programs is also briefly described in Sections 3.2.1 and 3.2.2.

Table 3.7 SUMMARY OF DOD/TACOM CONFORMANCE WITH REGULATORY REQUIREMENTS PROGRAM

Descriptive Title of Task	Investigator	Fiscal Year Funding ($1,000) 1973	1974	1975
TACOM Noise Measurements, Standards and Coordination	In-House	50	120	
Construction of an Anechoic Test Facility For Vehicle and Vehicle Components	Eckel Corporation	90		
Noise Measurement Test of Military Fleet Vehicles	In-House		53	
Isolation and Measurement of Component Noise Emissions of a M813 5-ton Cargo Truck	Cummins Engine Company		9	
TACOM/DOT Noise Measurements of Non-Directional Cross Country & New Military Tires	National Bureau of Standards		20	
Purchase of Sound and Vibration Measurement and Analysis Equipment	In-House	75	13	
Noise Reduction of an M813 5-ton Cargo Truck	E. L. Blachford, Inc.		23	
Modification of a Mobile Laboratory Van	PSI, INC.		32	
	TOTALS	215	270	-

Table 3.8 SUMMARY OF DOD/TACOM VEHICLE SIGNATURE PROGRAM

Descriptive Title	Investigator(s)	Fiscal Year Funding ($1,000) Prior to 1973	1973	1974(est)	1975
Noise Signature Measurement Program	In-House	100	50		
TACOM Analysis of Armored Reconnaissance Scout Vehicle Contractor Program to Reduce Exhause System Noise, Noise Reduction of the M561 GAMA Goat, & Information Dissemination	In-House		50		
Vehicle Noise Specifications and Field Tests of Het-70 and M520 Goer Pilot Vehicles	In-House			37	
Military Vehicle Track Modelling Noise and Vibration Study	Bolt, Baranek & Newman			28	
Computer Correlation of Vehicle Detectability	Bolt, Baranek & Newman			30	
	TOTALS	100	100	95	

Table 3.9 SUMMARY OF DOD/NERDC NOISE REDUCTION PROGRAM FOR U.S. ARMY CONSTRUCTION VEHICLES

Descriptive Title	Investigator	Fiscal Year Funding ($1,000) 1973	1974	1975
Off-Road Vehicle Noise Survey				
Operator Noise Exposure	In-House and Dayton T. Brown, Inc.*	44	+	
Exterior Noise	In-House**	+	+	+
Noise Specification/Standard Development	In-House	+	+	+
	Total	(44)	(+)	(+)
Vehicle Noise Control				
D7 Crawler Tractor	Caterpillar Tractor Co. and In-House	130		
6K Rough Terrain Forklift Truck	Dayton T. Brown, Inc. and In-House	75	30	
10K Rough Terrain Forklift Truck	H. L. Blachford, Inc. and In-House	75	30	
830 M3 Wheeler Tractor	Kamperman Associates, Inc. and In-House		60	80
6K Warehouse Forklift	Allis-Chalmers		140	65
	Total	(280)	(260)	(145)
Component Noise Control/Control Components				
Hydraulic Noise	Oklahoma State University	20	40	10
Acoustical Materials	Dayton T. Brown, Inc. and H. L. Blachford	25		5
	Total	(45)	(40)	(15)
	GRAND TOTAL	369	300	160

* Subcontract to Kamperman Associates, Inc.
** Also in conjunction with the "Vehicle Noise Control Program"
\+ Not dedicated to noise

3.2.1 TACOM Surface Vehicle Noise Reduction Program

Conformance with Regulatory Requirements - The objective of this effort is to measure and reduce noise levels of all military vehicles that fall within the jurisdiction of military and commercial noise standards. Both interior and near field exterior noise emissions are considered. The following standards are among those that are addressed:

Table 3.10 SUMMARY OF MILITARY AND COMMERCIAL NOISE STANDARDS

Title	Source	Portion of the Vehicle Affected		
		Int.	Ext.	Nondetectability
MIL STD 1474 (MI) Noise Limits for Army Material	Army	X	X	X
TB 251	Army	X		
Public Law 92-574 Noise Control Act of 1972	Federal	X	X	
MIL H 46855 Human Engr Request for Military Systems	Army	X		
MIL STD 1472 Human Engr Design Criteria	Army	X		
EPA Proposed Standards	Federal		X	
Federal Motor Carrier Safety Regulation	Federal	X		
Occupational Safety & Health Act (OSHA)	Federal	X		

The Conformance with Regulatory Requirements Program was initiated in FY 73. The following represents a distribution of the resources by tasks and the work accomplished:

TACOM Noise Measurements, Standards and Coordination - This in-house project consisted of a number of tasks. For example an Army Materiel Command (AMC) Working Group on noise formulated Military Standard (MIL STD) 1474 (reference 52). Existing military vehicle noise test data were compiled and additional "quick" tests were run at the Yuma Proving Ground (YPG). Two TACOM reports were published (references 53,54). A coordination effort on interior noise included developmental measurements and noise reduction cost estimates on M551, M746, M123, M578, and M114 vehicles. Cooperative efforts were undertaken with other TACOM agencies to establish the following ranking of vehicles requiring measurement of interior and exterior noise emission.

(1) M35A2 Cargo Truck
(2) M818 Tractor Truck
(3) M813 Cargo Truck
(4) M817 Dump Truck
(5) M151A1 Jeep
(6) M561 Gama Goat
(7) M746 Heavy Equipment Transporter
(8) M520 Cargo Goer
(9) M559 Tanker Goer
(10) M553 Wreaker Goer

In addition, TACOM transferred $10,000 to the U.S. Army Test and Evaluation Command (TECOM) at the Aberdeen Proving Ground (APG) for a MIL STD 1474 interior and exterior noise measurement of 3 new samples each of M151A2 and M561 vehicles (this was a "piggy back" measurement on a vehicle product assurance test). Resources for this effort were increased to $100,000 in FY 74. Emphasis was in assisting in revisions to MIL STD 1474, support of measurement and suppression of noise on several types of high mobility tactical vehicles, and coordination of contract efforts.

Anechoic Test Facility Construction - This project resulted from the transfer of $165,000 from another TACOM Division for truck engine noise reduction work (DA Project 1G563621DG07). The effort was as follows: A $90,000 contract was awarded Eckel Corporation for the construction of a semi-aechoic test facility. Noise measurements on vehicles, engines and transmissions may be accomplished in this facility which will accomodate vehicle sizes up to and including the 5-ton M809 series truck. $75,000 was utilized for noise measurement equipment for the chamber.

Noise Measurement Test of Military Fleet Vehicles - A TECOM noise

measurement test of military fleet vehicles was initiated in FY 74 using MIL STD 1474 test criteria. The test location was the Aberdeen Proving Ground. Five vehicles, each of seven types, were tested. The types were M151A1, M561, M35A2, M35A2C, M818, M813, and M817. The testing was completed in July 1974.

Isolation and Measurement of Component Noise Emissions of an M813 5-ton Cargo Truck - This contract with Cummins Engine Company was initiated in July 1973 and was designed to isolate and measure component noise emission on one M813 5-ton cargo truck. The testing was completed in August 1973.

TACOM/DOT Noise Measurement of Non-Directional Cross/Country (NDCC) & New Military Tires - This joint effort was conducted by NBS at Wallops Island, Virginia. The tests were run from July through September 1973, and a report (reference 55) was published.

Purchase of Sound and Vibration Measurement and Analysis Equipment - This equipment was purchased for in-house use in FY 1973 and FY 1974.

Noise Reduction of an M813 5-ton Cargo Truck - A contract was let with H. L. Blachford, Inc., for the period of September 1973 to June 1974 to reduce the interior and exterior noise levels of an M813 5-ton cargo truck to conform with MIL STD 1474 criteria and to provide data on cost versus noise reduction achieved. A report (reference 57) has been published on this work.

Modification of a Mobile Laboratory Van - A contract was negotiated with PSI, Inc., to facilitate installation of new noise measurement equipment in the TACOM mobile laboratory van. The contract duration was December 1973 to July 1974.

Vehicle Signature Reduction

Noise Signature Measurement Program - This in-house effort by TACOM directly assisted the project manager of Remote Battlefield Sensor Systems (REMBASS) by providing data reduction and a report on a classified signature program. Noise signatures were measured on the following military vehicles:

Tracked	Wheeled	Aircraft
M60	M151A2	UH1H
M551	M35A2	CH46
M113A1	M813	T33
M114	M561	C130
M578	GAZ59	
M109	ZIL157	
PT76		

A TACOM report (reference 56) was published. Previously obtained data on combat vehicles were analyzed to determine the attenuation of various frequencies of the noise signatures with distance. Transcription of vehicle noise data tapes were transmitted to the Naval Air Development Center (NADC), the U.S. Air Force Rome Air Development Center (RADC), the U.S. Army Mobility Equipment Research and Development Center (MERDC), and the Army Crop of Engineer's Waterway Experiment Station (WES).

TACOM Analysis of the Armored Reconnaissance Scout Vehicle (ARSV) Contractor Program to Reduce Exhaust System Noise, Noise Reduction of the M561 GAMA Goat, and Information Dissemination - The ARSV (XM800) contractor tests of the plans for reducing exhaust system noise were reviewed and recommendations transmitted to the project manager. Evaluation and reduction of noise sources on the M561 Gama Goat was partially accomplished (continued in FY 74). As the Research and Engineering Directorate's prime proponent for noise reduction, information was disseminated to and technical inquiries answered from other TACOM organizations.

Vehicle Noise Specifications and Field Tests of HET - 70 and M520 Goer Pilot Vehicles - This in-house task involved providing assistance to project managers on noise inputs to vehicle specifications and performing noise field tests on HET-70 and M520 Goer pilot vehicle.

Military Vehicle Track Modelling Noise and Vibration Study - This contract is with Bolt, Beranek, and Newman (BBN) of Chicago and involves the reduced scale modelling of a combat vehicle track to determine the contribution of various track and suspension components to vehicle noise.

Computer Correlation of Vehicle Detectability - This contract is also with BBN and has produced a computer program for the prediction of vehicle detection ranges. A report (reference 58) of this work has been published.

Future Objectives of the TACOM Program - For the period of FY 75-78, the DOD/TACOM noise research program objectives can be summarized as follows:

1. Continue TECOM-APG Vehicle Noise Measurement Program.

2. Isolate and measure component noise on all offending vehicles measured in the Conformance with Regulatory Requirements Program.

3. Conduct cost effective noise reduction work on offending components measured in the Vehicle Signature Program.

4. Continue liaison with other government and commercial organizations involved in noise standards and noise reduction.

5. Continue work with Army Vehicle Project Managers and engineers on new vehicles under development and on vehicle product improvement programs.

6. Investigate computer modeling techniques for prediction of component noise contribution to the total vehicle noise output and for prediction of vehicle aural security distances.

3.2.2 MERDC Noise Reduction Program for U.S. Army Construction Vehicles

Off-Road Vehicle Noise Survey

Operator Noise Exposure - To evaluate the average noise reduction requirements of much of MERDC construction equipment, a noise exposure monitoring program was initiated. This noise program required evaluation of several instrumentation systems to measure average noise levels. These systems included tape recordings analyzed by digital computer, analysis of noise on site with a statistical distribution analyzer, and analysis with commercially available noise dosimeters. The first noise exposure monitoring site was the Army Engineer Training Center at Fort Leonard Wood, Mo. In general, these techniques showed the average noise level to be lower than that determined by simple sound level (reference 67) over a short interval (reference 69,74).

Exterior Noise - Exterior noise measurements were made on U.S. Army construction vehicles at Ft. Belvoir, Virginia. Measurements were made at 15.24 meters (50') in accordance with SAE criteria (reference 70). In addition similar measurements were made in conjunction with the "Vehicle Noise Control Program."

Noise Specification/Standard Development - An informal evaluation and study of noise standards and criteria was carried out over a period of time in conjunction with other government agencies and industry groups. Primary criterion that had to be met was the noise exposure criterion of the Army Surgeon General (i.e., no soldier should be exposed to more than an average of 85dB(A) over an 8 hour period). This criterion dictated the need to evaluate the energy average of the machine noise reaching the operator's ear. This evaluation was rather difficult because the average, normal, or typical use of the equipment was not defined. To overcome this problem, a baseline noise exposure monitoring program was carried out as described in the "Operator Noise Exposure" project above. The results of these studies were incorporated in MIL STD 1474A to be published in March 1975 (reference 71). This standard will present design guidelines for implementing usage standards such as the Army Surgeon General Criterion and the OSHA noise regulations.

Vehicle Noise Control

D7 Crawler Tractor - An initial effort was made to determine the major problems that would be anticipated in requiring a low noise polluting vehicle and what were the practical limitations. In 1972, a contract was awarded to Caterpillar Tractor Co. to study a military version of the D7 crawler tractor with the following goals:

1. Measure the variation of noise on production line vehicles and develop baseline data.

2. Determine each major source of noise and establish the noise level of each.

3. Reduce the noise at each source as far as practical and determine the effects on vehicle performance.

4. By use of external means, reduce the noise level to 90dB(A).

5. Provide a feasibility study of reducing the noise to 90dB(A) in the operator's compartment while the vehicle is moving.

6. Reduce the noise level to the lowest possible level.

7. Develop practical means of reducing the noise level effect resulting from the addition of rollover protective structures (ROPS).

This report provided a voluminous amount of information (reference 72), thus, only a summary of the results is provided here.

The major noise sources identified in the study were engine block, fan, exhaust, hydraulic pump, drive train, power train, and track. In addition to noise reduction work on the engine, exhaust, fan, and hydraulic system, work was performed on the overall machine configuration to block off the noise. Two major areas considered were the engine and operator compartments. The end result was that the noise level was reduced substantially from 99 to 91dB(A). This was a relatively simple package in respect to maintenance and almost met the original objective of 90dB(A). Reducing the fan speed 10% met the objective but provided insufficient airflow and cooling. The only other major sources of noise which could not be adequately addressed were the hydraulics and track.

The overall result (reference 73) was a package for retrofit of the basic vehicle noise but did little for track noise. The level did not meet the goal of 90dB(A), let alone the Surgeon General's criterion of 85dB(A), and cost would have been several thousand dollars. As a

result, it was felt that retrofit of these machines in the field would not be appropriate.

6K Rough Terrain Forklift Truck - The program on the 6000 lb. capacity (6K) truck was awarded under a time and materials contract to Dayton T. Brown, Inc. The contractor was to proceed step by step as directed by the MERDC. The initial noise level of the vehicle was 99dB(A) at high idle (HI), and after initial noise reduction modifications were accomplished, the HI noise level was about 88dB(A). From this configuration several additional noise reduction methods were sought, and the initial modifications were reworked to make them more practical. The dominant noise source at this point was the fan, since its complete removal reduced the overall noise level to 86dB(A) and no other source was as significant. In accordance with previous findings, major emphasis was placed on a new shroud system. This, in conjunction with additional absorption material in the engine compartment, reduced the overall noise level to 87dB(A) at HI (reference 73).

10K Rough Terrain Forklift Truck - The 10,000 lb. capacity (10K) forklift noise control program was awarded as a fixed price level-of-effort contract to H. L. Blachford, Inc. Blachford was to proceed without knowledge of the work of the 6000 lb. capacity forklift program contractor. The initial HI noise level for this vehicle was 102dB(A) but this was reduced to 91dB(A) using similar treatments as with the 6K vehicle. In addition, a shield was placed behind and to the side of the operator, providing an additional 4dB(A) reduction to 87dB(A) (references 68,80).

The average noise levels of both of the 6K and 10K forklifts in typical operation were within the 85dB(A) requirement. Since these two items of equipment are relatively large materials handling vehicles and are similar to construction vehicles, particularly loaders, it is felt that almost any item of wheeled equipment can be reduced to a safe average noise level.

830 MB Wheeler Tractor - The 830 MB noise control program was initiated in January 1974 to reduce the operator noise of the tractor to 85dB(A) average. In conjunction with other efforts in the Vehicle Noise Control Program, a methodology for conducting similar programs is being developed. The 830 MB Wheeler Tractor study and the status and results of the Vehicle Noise Control Program are reviewed in reference 75. The 830 MB Wheeler Tractor program is to be completed in FY 1976.

6K Warehouse Forklift - This program was initiated to determine the average noise level of this commercially available vehicle, to reduce the average noise levels to 85dB(A), and to evaluate the feasibility of reducing the noise level to 85dB(A) maximum. Engineering is to be completed by FY 1976.

Hydraulic Noise - One of the more difficult problems is the reduction of hydraulic noise. Major efforts were involved in isolating mounts and covering up components, but it was felt that further basic work was needed. The initial approach was to try to select a "quiet" pump, but it was determined that there were no satisfactory standards for measuring the noise of pumps. Work was done in conjunction with Oklahoma State University (OSU) and the National Fluid Power Association (NFPA) to develop a procedure which has subsequently been submitted to the International Organization of Standardization (ISO). As the vehicle studies progressed, it became apparent that although most pumps are rated as to the amount of noise they emit to the air, the real problem is the amount of "noise" that is fluidborne and is released downstream at the hoses, valves, and reservoirs. Levels reached the equivalent of over 200db(A). It is interesting to note that in either case the noise is more adversely dependent upon the shaft speed than system pressure, but this is more true for fluidborne noise. In this study, no attempt was made to develop a "quiet" pump but rather to give an effective means to tradeoff performance parameters in order to reduce noise. Present work has been generally to study the phenomenon of noise in hydraulic systems. This will continue in the future along with the development of practical means to reduce noise (references 76,77).

Acoustical Materials - During the studies on various vehicles, it was necessary to use a wide range of absorption, damping, and barrier materials. An attempt was made to select materials that would be compatible with field operations. Construction equipment operates in a severe environment, and military equipment has special problems of temperature extremes, long periods of non-usage, and limited cleaning facilities. Some difficulty was experienced in obtaining data on materials relating to the effects of solar radiation, impregnation with dust and oil mist, steam-cleaning battery acid, etc.

A series of tests were developed to simulate field conditions and these were put in typical sequence. For example, one test related to placing oil on a material exposed to high temperature and steam-cleaned. Test procedures are given in reference 78.

3.3 EPA SURFACE VEHICLE NOISE RD&D PROGRAMS

3.3.1 Support of Regulations Development

The surface vehicle noise RD&D sponsored by the EPA is principally associated with the development of surface transportation regulations specified in the Noise Control Act of 1972. Specifically, the EPA research has supported the development of regulations for control of noise

from interstate motor carriers, interstate rail carriers, and new medium and heavy duty trucks. A summary of the EPA research on surface vehicle noise is presented in Table 3.11. The details of these activities are described below.

Interstate Motor Carriers - A contract effort with Wyle Laboratories was undertaken in June 1973 to conduct a cost and technology assessment of the motor carrier industry with regard to noise abatement applications. The contractor was to review all major noise emitting operations of interstate motor carriers and describe them. This description was to include, but not be limited to, a characterization of the noise profile, an estimate of the number of people impacted by the noise, and an assessment of how these people are impacted. In describing the technology available to retrofit interstate motor carriers for compliance with varying degrees of noise control, cost estimates were made of each level of noise control achieved. Final reports (references 82,83) on this contract have been submitted to EPA. The cost of this contract was $130,000.

The services of Bolt, Beranek and Newman (BBN) were obtained through the basic ordering agreement procedure for direct analysis work on the dockets submitted during the development of the interstate motor carrier regulation. No specific reports were produced but the output from this effort was recorded in memorandums on a continuing basis during the period of the contract and has been incorporated in the EPA background document (reference 84) for the interstate motor carrier noise regulation. Value of the basic ordering agreement for this effort was $30,000.

Interstate Rail Carriers - Bolt, Beranek & Newman was awarded a contract to assess the technology and cost of retrofit of the interstate rail carrier fleet for compliance with various noise control levels as determined by the availability of technology. This contract included an assessment of available technology and the cost incurred to apply those specific elements of available technology. Also, this contract involved an analysis of the impact on the population from railroad noise and the projected incremental changes in that impact as a result of technology application to railroad noise sources. A series of draft reports were prepared by the contractor and submitted to EPA for review. The result of this study in major part was included in the background document (reference 85) prepared by EPA and made available to the public at the time of the publication of the proposed railroad regulation. This contract effort is now complete and the level of funding was $134,000.

As a result of additional requirements to refine the data base in support of the proposed rail carrier regulation, BBN was contracted through a basic ordering agreement to do additional specific work on the

Table 3.11 SUMMARY OF EPA SURFACE VEHICLE NOISE RESEARCH ACTIVITIES

Descriptive Title	Investigators	Total Fiscal Year Funding ($1,000) 1973	1974	1975[1]
Interstate Motor Carriers	Wyle, BBN	170		
Interstate Rail Carriers	BBN & NBS	199		
New Medium and Heavy Duty Trucks	Wyle, BBN, A. T. Kearney & NBS		178	
	TOTALS	369	178	

(1) No FY 75 fiscal data available

application of mufflers to the in-use locomotive fleet and to assist with the analysis of the railroad docket. This effort is still underway although several informal memorandums including additional data have been submitted to EPA. Some of the information generated by this effort is included in the background document (reference 85) published in support of proposed rail carrier regulation. The amount of this contract effort was $40,000.

The National Bureau of Standards through an interagency agreement conducted a series of studies on railroad noise emission levels and has published a joint EPA/NBS report (reference 86) on the results of their study. The level of funding for this study was $25,000.

New Medium and Heavy Duty Trucks - Wyle Laboratories was contracted to conduct an initial assessment of the cost and technology required to produce new trucks having various levels of noise emissions. This was an initial state-of-the-art study to assess available noise control technology and to provide cost estimates representing the application of this control technology. This study has been completed and a final report (reference 87) is available. Cost of this study was $17,000.

Bolt, Beranek & Newman was contracted to continue the work in technology and cost assessment initiated by Wyle Laboratories in refining the data base upon which the medium and heavy duty truck regulation could be developed. This effort involved a more detailed look at the available technology and specific cost estimates to apply that technology and was conducted in conjunction with the economic analysis by A. T. Kearney (see below). The overall objectives were to provide a total assessment of potential regulatory levels of noise control on the industry and to form a basis for the Federal regulatory action. This contract was completed in January 1974. The amount of this contract effort was $110,000.

A. T. Kearney was contracted to do an indepth economic analysis based on the cost estimates established during the study on the impact of various strategies of noise control on medium and heavy duty trucks. This analysis included both domestic and import/export impacts as a result of various noise control strategies. This contract has been completed. The resources required for this contract were $41,000. The results of the BBN and A. T. Kearney studies have been combined and included in the EPA background document (reference 88) for the proposed medium and heavy truck noise regulation.

The National Bureau of Standards was asked, through interagency agreement, to assess measurement methodologies which had highest potential for use in a noise control regulation for medium and heavy duty trucks. The final report (reference 89) of this study has been completed and is available from either NBS or EPA. The amount of resources for this study was $10,000.

3.4 USDA SURFACE VEHICLE NOISE RD&D PROGRAMS

Surface vehicle noise RD&D activities are sponsored by the USDA Forest Service and Cooperative State Research Service. Their programs are summarized in Table 3.12 and are briefly described below.

3.4.1 Forest Service Programs

The broad mission and objective of the Forest Service is to manage and enhance the value of National Forests for the benefit of all U.S. citizens. Forest Service Research is undertaken to develop the knowledge and technologies required to accomplish this mission for all of America's forests and related lands. The Forest Service noise abatement programs are directed to improving both our living and working environments (a) by effectively using trees and shrubs in the reduction of outdoor noises and (b) by systematic development efforts directed toward reducing vehicle and equipment noise levels. Accordingly the Forest Service has undertaken the following two programs.

Use of Trees and Shrubs in Noise Abatement - Currently this program is being carried out at Lincoln, Nebraska, in cooperation with the Department of Engineering Mechanics, University of Nebraska. It is supported by a cooperative grant of $20,000 (FY 74). It is the purpose of this study to determine means for controlling intrusive noise by combining trees and shrubs with land-forms or other solid barriers. The combined use of solid barriers and plant material provide a usable and practical approach for reducing noise levels under a number of conditions. This study will develop guidelines for intrusive noise control. Additional studies of this type are not planned following completion of the current series of investigations. References 90, 91, and 92 are recent publications.

Reduction of Vehicle and Equipment Noise Levels - This program is being carried out at the Equipment Development Center, San Dimas, California, with current expenditures of: FY 74, $25,000, and FY 75, $39,000. Equipment development efforts are directed toward reducing the noise level of equipment used in and about forested areas both for improving the environment and for the improved health and safety of forest workers. This is an ongoing program of the Forest Service and funding is expected to remain at about this level in the future. Special equipment for this program is currently available at the San Dimas Equipment Development Center. References 93 and 94 are recent publications.

Table 3.12 SUMMARY OF USDA SURFACE VEHICLE NOISE RD&D PROGRAMS

Descriptive Title	Investigator	Fiscal Year Funding ($1,000) 1973	1974	1975
Use of Trees and Shrubs in Noise Abatement	Univ. of Nebraska		20	
Reduction of Vehicle and Equipment Noise Levels	In-House		25	39
Noise and Vibration of Off-Road Equipment(1)	Univ. of Illinois	4(29)	28(58)	
	TOTALS	4	73	39

(1) Values in parentheses are total resources for the project. Other values are the Federal contribution to the study.

3.4.2 Cooperative State Research Service Program (CSRS)

Research on noise is supported as individual scientists or engineers submit projects that are approved by CSRS. The Director of the Agricultural Experiment Station, the Administrative-Technical Representative of Forestry Schools where the research is located is responsible for allocations of CSRS administered formula funds to approved projects. Grant funds are allotted to projects generated again by university scientists.

The CSRS program for noise research encourages research activities that are sound from the standpoint of science and engineering, reviews projects submitted for funding approval, and coordinates research activities among the States and with other USDA research programs.

The noise research project pertinent to surface vehicle noise is entitled, "Noise and Vibration of Off-Road Equipment". The study is being conducted at the University of Illinois, Urbana and extends from 1-7-70 to 3-6-73.

3.5 NSF SURFACE VEHICLE NOISE RESEARCH

NSF sponsors research based upon the merits of unsolicited proposals. Of these, there are three NSF noise research studies relating to surface vehicles. These are identified in Table 3.13 and are briefly described below.

Basic and Applied Studies of Noise - Specific work supported under this grant will be basic research on the mechanics of tire noise, sound generation and propagation in internal flows, and practical applications of pitch sequencing. In the surface vehicle related portion a study will be made of the sound generation by tire automotive tread patterns under controlled laboratory situations. The objective will be to determine the amplitude and phasing of the directional sound generation from single tread configurations, with a view towards using this information in a superposition analysis of more complex patterns eventually leading to quieter system designs.

Since the emphasis in this work is in noise from internal flows, the resource allocations have not been included in the Federally sponsored surface vehicle RD&D.

Effects of Building and other Boundaries on Motor Vehicle Noise - The goal of the investigation is to find ways and means to reduce the spread of noise pollution resulting from motor vehicles on highways, thoroughfares, and urban rapid transit systems. The program will utilize large models in an anechoic chamber, supplemented by field studies.

Table 3.13 SUMMARY OF NSF SURFACE VEHICLE NOISE STUDIES

Descriptive Title	Investigators	Fiscal Year Funding ($1,000) 1973	1974	1975
Basic and Applied Studies on Noise(1)	Stanford Univ.		(87)	
Effects of Buildings and Other Boundaries on Motor Vehicle Noise	UCLA		30	
Noise and Vibration from Transportation Vehicles and Other Machinery	Purdue Univ.		272	
	TOTALS		302	

(1) Only minor portions of this study are related to surface vehicle noise. Therefore, the total resources in parentheses are not included in the totals.

Noise and Vibration from Transportation Vehicles and Other Machinery - To complement the ongoing research at the Ray W. Herrick Laboratories of Purdue University, a broad range of research projects in noise control and accoustics will be undertaken. These include: enclosure design, automobile engine noise source identification and reduction, noise attenuation measurements in mufflers, tire noise generation, appliance noise reduction, machine tool noise reduction, barrier design, community noise from rapid transit vehicles, and other projects. A new addition, a semi-anechoic facility will be built to accommodate many of the new projects. It has been assumed that the principal activities in this effort will relate to surface vehicle noise and therefore have included all of the identified resource commitments in the Federal surface vehicle noise RD&D category.

3.6 NBS SURFACE VEHICLE NOISE RD&D

There is currently no surface vehicle noise RD&D being sponsored by the NBS. However, NBS does conduct research on surface vehicle noise through interagency agreements. The description of work is provided in Appendix D. Table 3.14 is a listing of these studies. The resources identified are included in the sponsoring agencies resource allocations for surface vehicle noise RD&D.

Table 3.14 SUMMARY OF NBS SURFACE VEHICLE RD&D SPONSORED THROUGH INTERAGENCY AGREEMENTS

Sponsoring Agency	Descriptive Title	Fiscal Year Funding ($1,000) Prior ot 1973	1973	1974	1975
DOT	Truck Tire Noise Studies (1)	468	100	100	200
DOD	Noise Evaluation Tests of Military Truck Tires			20	
EPA	Train Noise Study		25		
	Methodology for the Measurement of Noise from Trucks			10	
	TOTALS	468	125	130	200

(1) Includes interior/exterior truck noise and automobile tire noise.

4. ANALYSIS OF THE FEDERAL SURFACE VEHICLE NOISE RD&D ACTIVITIES

The Federal research activities to control surface vehicle noise have been presented in Section 3 as integrated programs and/or projects as developed and implemented by the agencies. As such, Section 3 provides the perspective by which each agency views and treats the noise problem associated with surface vehicles.

It is also useful, however, to examine the Federal programs collectively to identify related and/or complementary activities which are addressing specific sources or systems of surface vehicle noise. From such an analysis, the emphasis in the current Federal efforts can be ascertained. Section 4 provides a brief analysis to identify the surface vehicle sources or systems which are receiving major emphasis in the current Federal effort.

Surface vehicle sources of noise include mobile systems used in transportation, construction, defense, recreation, and agriculture. The Federal surface vehicle noise control technology RD&D programs can generally be classified according to three, all inclusive noise source categories. These are highway vehicle noise, railway vehicle noise, and off-highway vehicle noise. Highway vehicle noise sources include trucks, buses, passenger cars, motorcycles. Railway sources encompass conventional and highspeed or rapid transit railroad systems. Off-highway vehicles include construction and agricultural equipment, snowmobiles, and motorboats.

In addition to the development of noise control technology for individual sources, there are other Federal research activities dedicated to noise. They are those associated with the characterization and/or control of collective or area noise sources such as highways, construction sites, and railway yards, and with the development and enforcement of standards and regulations. Federal research in these areas can be classified as those concerned with systems studies of noise and with regulations support and enforcement.

Other Federal RD&D programs which are associated with noise are the development of future or advanced surface vehicle systems. Although not dedicated to noise, these programs can have a major impact on the control of surface vehicle noise. Consequently, these programs have been separately identified. However, specific noise tasks identified in these programs will be related to the appropriate noise dedicated activity.

Table 4.1 is a summary of the Federal resource commitments for RD&D programs addressing highway vehicle, railway vehicles and off-highway vehicles noise control technology development, surface vehicle noise systems studies, and regulations and enforcement. Federal allocations

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Table 4.1 SUMMARY OF FEDERAL SURFACE VEHICLE NOISE RD&D ACTIVITIES

Noise Category	Agency		Fiscal Year Funding ($1,000) Prior to 1973	1973	1974(est)	1975*
Highway Vehicle Technology	DOT	TOTAL	1,708	802	727	695
Railway Vehicle Technology	DOT	TOTAL	-	330	250	
Off-Highway Vehicle Technology	DOT		-		50	
	DOD/ARMY		100	469	395	160
	USDA		-	4	53	39
		TOTAL	100	473	498	199
Noise Systems Studies	DOT		301	350	857	310
	NSF		-	-	302	-
	USDA		-	-	20	-
		TOTAL	301	350	1,179	310
Regulations and Enforcement	DOT		57	672	272	130
	EPA		-	369	178	-
	DOD/ARMY		-	215	270	-
		TOTAL	57	1,256	720	130
Advance Systems	DOT		Noise resource allocations not available			
		TOTAL	2,166	3,211	3,374	1,334

*FY 75 estimates known to be incomplete

for the noise portions of advanced surface vehicle systems development are not separable from other development costs and have not been estimated. A brief discussion of the federal research activities in these categories is presented in the following sections. There are programs which have activities which relate to more than one category. In these cases, the programs have been identified with resources assigned to the category of greatest emphasis. However, the programs are also listed in the other pertinent categories if appropriate.

4.1 HIGHWAY VEHICLE NOISE CONTROL TECHNOLOGY RD&D

Table 4.2 contains a listing of Federal RD&D activities associated with the development of control technology for highway noise sources. The primary emphasis in these efforts is truck noise, although major efforts are indicated for control of bus noise. The majority of the Federal efforts are those sponsored by DOT and address all of the major component sources of truck noise. Future emphasis in control of truck noise is in truck tires and engine mechanical and combustion noise.

4.2 RAILWAY VEHICLE NOISE CONTROL TECHNOLOGY RD&D

The Federal RD&D programs directed toward the development of noise control technology for railway noise sources are listed in Table 4.3. While only one technology development program has been identified specifically for conventional rail vehicles, several major programs have been identified for rapid transit systems. DOT is the only agency sponsoring noise control RD&D for railway vehicles.

4.3 OFF-HIGHWAY VEHICLE NOISE CONTROL TECHNOLOGY RD&D

The Federal RD&D programs directed toward the development of noise control technology for off-highway vehicle noise sources are listed in Table 4.4. These efforts address tracked and wheeled military combat and construction vehicles, snowmobiles, and conventional diesel-engine-powered construction equipment and are sponsored by DOD/ARMY, USDA, and DOT. Although not identified specifically, there is evidence that DOD/Navy sponsors some noise control technology RD&D in this category, principally for watercraft. However, much of the DOD sponsored noise control RD&D is classified and therefore not presently available for general use. Much of the noise control technology being developed for off-highway vehicles will have potential applications to the similar highway vehicles and vice-versa.

Table 4.2 FEDERAL CONTROL TECHNOLOGY RD&D PROGRAMS FOR HIGHWAY NOISE SOURCES

Noise Sources	Descriptive Title of Program	Sponsoring Agency	Fiscal Year Funding ($1,000) Prior to 1973	1973	1974(est)	1975*
Trucks	Quiet Truck Program	DOT	1,046	100	100	-
	Truck/Bus Retrofit	DOT		450	72	-
	Exhaust/Intake Mufflers	DOT	75	28	-	-
	Truck Noise Handbook	DOT		15	20	-
	Basic Engine Noise Reduction	DOT			245	245
	Truck Tire Noise Study	DOT	468	100	100	200
	Truck Tire Noise Basic Research	DOT	119	-	150	250
	Engine Noise Support	DOT		80	40	-
	Vehicle Signature Program (See Table 4.4)	DOD/ARMY				
Buses	Truck/Bus Retrofit (see above)	DOT				
	Transit Bus Noise Reduction Potential	DOT		26		
	Transbus Program (Advanced System)	DOT	++	++	++	++
Passenger Cars	Passenger Car Tire Noise	DOT		3	+	
	Basic and Applied Studies of Noise (See Table 3.13)	NSF				
	TOTAL		1,708	802	727	695

* FY 75 estimates known to be incomplete
\+ Primarily inhouse effort
++ Program is not dedicated to noise resource allocations not available.

Table 4.3 FEDERAL CONTROL TECHNOLOGY RD&D PROGRAMS FOR RAILWAY NOISE SOURCES

Noise Sources	Descriptive Title of Program	Sponsoring Agency	Fiscal Year Funding ($1,000) Prior to 1973	1973	1974(est)	1975*
Conventional Railway	Joint DOT/AAR Noise Research	DOT	(Noise Systems Study, Table 4.5)			
Rapid Transit	Wheel/Rail Noise & Vibration Study	DOT	-	184		
	Elevated Structures Noise and Vibration	DOT	-	146		
	In service Noise Abatement Test and Evaluation	DOT	-	-	250	
	TOTALS			330	250	

* FY 75 estimates are known to be incomplete
\+ In-House
++ Programs not dedicated to noise, noise resource allocations not available

Table 4.5 FEDERAL CONTROL TECHNOLOGY RD&D PROGRAMS FOR OFF-HIGHWAY VEHICLE NOISE SOURCES

Descriptive Title of Program	Sponsoring Agency	Noise Sources	Fiscal Year Funding ($1,000) Prior to 1973	1973	1974(est)	1975*
Vehicle Signature Reduction	DOD/ARMY	Tracked Combat Vehicle Wheeled Combat Vehicle	100	100	95	
Noise Reduction Program for U.S. Army Construction Vehicles	DOD/ARMY	Construction Vehicles		369	300	160
Reduction of Vehicle & Equipment Noise Levels	USDA	Snowmobile Engine Cooling Fans Exhaust			25	39
Noise and Vibration of Off-Road Equipment (See Table 3.12)	USDA	Farm Equipment		4	28	
Construction Equipment Mufflers	DOT	Construction Vehicles			50	
		TOTALS	100	473	498	199

*. 75 estimates are known to be incomplete

4.4 SYSTEM STUDIES OF SURFACE VEHICLE NOISE

A number of Federal research programs have been identified which address noise generated by surface vehicle systems. These studies are dedicated to noise and are generally multifaceted. They can encompass development and testing of noise measurement methods, characterization of noise generated and noise systems, modeling of noise, identification of noise control methods, and RD&D of noise control technology. Since these studies are of a broad nature, the results can have many applications. However, portions of those studies which have specific noise source control technology development and demonstration objectives are identified with the appropriate individual noise sources in previous sections.

Table 4.5 is a listing of the known Federal noise studies of surface vehicle systems. These relate primarily to highways and rapid transit systems.

4.5 NOISE REGULATION AND ENFORCEMENT RESEARCH PROGRAMS

These research programs have been identified by the Federal agencies as direct support to the development of specific standards and regulations and the enforcement of regulations. While each study generally addresses a specific objective, collectively the projects encompass a broad range of subjects (i.e., measurements of source and area noise levels, development of measurement methodologies, training, state-of-the art technology, capital grants, etc.). However, the programs can be grouped by their relationship to highway, railway, or off-highway noise control. The identified Federal research projects relating to the development and enforcement of surface vehicle regulations are listed in Table 4.6. The emphasis in the current Federal efforts has been in support of highway noise regulations and enforcement.

4.6 ADVANCED SURFACE VEHICLE SYSTEMS DEVELOPMENT PROGRAMS

A number of Federal RD&D programs have been identified which relate to the development of advanced or future surface vehicle systems. These programs pertain exclusively to transportation systems and none are dedicated to noise. Consequently, resource allocations for the noise portions of the programs could not be readily ascertained. However, where specific noise related tasks or objectives were identified, they have been described in the appropriate sections on dedicated noise RD&D. Generally, however, the programs are of a very comprehensive nature and noise is considered principally as a design specification. Table 4.7 is a listing of the advanced surface transportation systems RD&D programs. The emphasis is on future mass transit systems and all are sponsored by DOT.

Table 4.5 FEDERAL SYSTEMS STUDIES OF SURFACE VEHICLE NOISE

Area of Study	Descriptive Title of Program	Sponsoring Agency	Fiscal Year Funding ($1,000) Prior to 1973	1973	1974(est)	1975*
Surface Transportation	Magnitude of Transportation Noise General & Potential Abatement	DOT	(1)	-	-	-
	Effects of Buildings and Other Boundaries on Motor Vehicle Noise	NSF			30	
	Noise and Vibration from Transportation Vehicles & Other Machinery	NSF			272	
Highway	NCHRP Project 117	DOT	120	120	180	
	Scale Modeling Highway Noise	DOT	79		-	-
	Scale Modeling Urban Traffic Noise	DOT	-	112	-	-
	Barrier Parametrics	DOT	+	+	50	+
	FHWA Highway Design Manual	DOT	-	54	-	-
	Highway Barrier Effectiveness	DOT	43	7	-	-
	Traffic Noise Study	DOT	43	37	37	-
	Community Noise Study	DOT	16	20	20	-
	Acoustic Materials Applications	DOT	-	-	115	110
	The Use of Trees and Shrubs in Noise Abatement	USDA	-	-	20	-
Railways	Joint DOT/AAR Noise Research	DOT	-	-	150	200
	Rapid Transit System Noise Environment	DOT	+			
	New York City Transit System Study	DOT			125	
	Chicago Transit Authority Studies	DOT			60	
	Other Transit Authority Studies	DOT			120	
	TOTALS		301	350	1,179	310

+ Primarily in-house
* FY 75 estimates known to be incomplete
(1) See Table 3.1

Table 4.6 FEDERAL RESEARCH PROGRAMS IDENTIFIED WITH NOISE STANDARDS AND REGULATIONS ENFORCEMENT

Program Area	Descriptive Title of Program	Sponsoring Agency	Fiscal Year Funding ($1,000) Prior to 1973	1973	1974(est)	1975*
Highway	In Cab Noise Tests	DOT	-	-		
	Highway Noise Enforcement Training and Equipment	DOT	-	450	70	-
	Roadside Enforcement Sites	DOT	-	-	100	50
	BMCS Training/Equipping	DOT				
	Development of Highway Noise Standards PPM 90-2	DOT	+	+	+	
	PPM 90-2 Training Manual & Course	DOT	-	132	+	+
	Purchase Specifications - Transit Coaches	DOT	-	-	22	-
	Interstate Motor Carrier Regulation	EPA		170	+	+
	New Medium & Heavy Duty Trucks Regulation	EPA			178	+
	Conformance with Regulatory Requirements	DOD/ARMY	-	215	270	-
Railway	New System Specifications - Capital Grants	DOT	++	++	++	++
	Measurement of Railroad Noise	DOT				
	Interstate Rail Carrier Regulation	EPA		199		
Off-Highway	Construction Equipment Standards	DOT	57	90	80	80
	TOTALS		57	1,256	720	130

\+ Primarily in-house
++ Program is not dedicated to noise, noise resource allocations indeterminate
* FY 75 estimates known to be incomplete

Table 4.7 FEDERAL RD&D OF ADVANCED SURFACE VEHICLE SYSTEMS: TRANSPORTATION

Type of System	Descriptive Title of Program	Sponsoring Agency	Fiscal Year Funding ($1.000) Prior to 1973	1973	1974	1975*
Bus	Transbus Program	DOT	++	++	++	++
Rapid Transit	Personal Rapid Transit (PRT) Program	DOT	++	++	++	++
	Linear Induction Motor Research Vehicle	DOT	++	++	++	++
	Magnetical Levitated Research Vehicle	DOT			+	+
	Tracked Air Cushion Research Vehicle	DOT	++	++	++	+
	Prototype Tracked Air Cushion Vehicle	DOT	++	++	++	++
	State of Art Car	DOT	++	++	++	+
	Screech Loop-Pueblo Facility	DOT	+	+	++	++
Mass Transit (General)	Dual Mode Program	DOT			++	++

\+ Primarily in-house
++ Program is not dedicated to noise, noise resource allocations indeterminant

5. REFERENCES AND BIBLIOGRAPHY

5.1 DEPARTMENT OF TRANSPORTATION

References

1. DOT Truck Noise Reduction Program, internal DOT description document, 26 pages plus reference page and nineteen figures and tables describing the planned facets of the DOT Truck Noise Program as of late 1972.

2. Close, W.H., "DOT's Four Point Program to Reduce Truck Noise, Automotive Engineering." Society of Automotive Engineers, February 1973, New York, New York. Volume 81, Number 2, pages 36-39. (This is a summarized version of Reference 1.)

3. Statement of Work DOT Request for Proposal OS-20095 for Diesel Truck Noise Reduction Project, Department of Transportation. Washington, D.C., March 1972. (This describes the work to be performed under the so called Quiet Truck Program.)

4. Kaye, Michael C., et al, Truck Noise IIIA Preliminary Noise Diagnosis of Freightliner Datum Truck-Tractor, Report Number DOT-TST-73-6 May 1973, Department of Transportation, Washington, D.C.

5. Kay, Michael C. and Ungar, Eric E., Truck Noise IIIB Acoustic and Performance Test Comparison of Initial Quieted Truck with Contemporary Production Trucks, Report Number DOT-TST-74-2 September 1973, U.S. Department of Transportation, Washington, D.C.

6. Averill, Dwight and Patterson, W.N., The Design of a Cost Effective Quiet Diesel Truck, SAE Paper 730714, presented at the West Coast Meeting, Portland, Oregon, August 20-23, 1973. Available from Society of Automotive Engineers, Inc., New York, New York.

7. Staadt, Richard L., Less Noise from Diesel Trucks, SAE Paper 730712, presented at the West Coast Meeting, Portland, Oregon, August 20-23, 1973. Available from Society of Automotive Engineers, Inc., New York, New York.

8. Thompson, J.W., An Engineering Approach to Diesel Truck Noise Reduction, SAE Paper 730713, presented at the West Coast Meeting, Portland, Oregon, August 20-23, 1973. Available from Society of Automotive Engineers, Inc., New York, New York.

9. Averill, Dwight and Patterson, W.N., The Design of a Quiet Diesel Truck, Noise Con 73 Proceedings, pages 50-55, October 15-17, 1973. Institute of Noise Control Engineering, Washington, D.C.

10. Landis, E.E., International Harvester's Approach to Diesel Truck Noise Reduction, Noise Con 73 Proceedings, pages 56-61, October 15-17, 1973. Institute of Noise Control Engineering, Washington, D.C.

11. Wheeler, Donald E., White Motor Approach to Diesel Truck Noise Reduction,Noise Con 73 Proceedings, pages 62-67, October 15-17, 1973. Institute of Noise Control Engineering, Washington, D.C.

12. Shrader, J.T., Cooling System Noise Reduction on Heavy Duty Trucks, Noise Con 73 Proceedings, pages 68-73, October 15-17, 1973. Institute of Noise Control Engineering, Washington, D.C.

13. Towers, David A., et al, Diesel Truck Engine Enclosure, Noise Con 73 Proceedings, pages 74-79, October 15-17, 1973. Institute of Noise Control Engineering, Washington, D.C.

14. Close, W.H., DOT Quiet Truck Program, Proceedings to Inter-Noise 74, Washington, D.C., October, 1974, pages 473-478.

15. Installation Status DOT Fan Clutch Program as of March 25, 1974, 1 page listing fan clutch manufacturer, number installed, truck type, fleet location and type of operation.

16. Hunt, Raymond E.; Kirkland, Kenneth C.; Reyle, Stanley P., Truck Noise VIA, Diesel Exhaust and Air Intake Noise, Report DOT-TSC-OST-73-12 July 1973, U.S. Department of Transportation, Washington, D.C.

17. Donnelly, Thomas; Tokar, Joseph; & Wagner, Wayne, Truck Noise VIB A Baseline Study of the Parameters Effecting Diesel Engine Intake and Exhaust Silencer Design, Report Number DOT-TSC-OST-73-38 January 1974, U.S. Department of Transportation, Washington, D.C.

18. Rowley, D.; Pridka, N., State-of-the-Art of Present Day Intake and Exhaust Systems, Noise Con 73 Proceedings, pages 80-85, October 15-17, 1973. Institute of Noise Control Engineering, Washington, D.C.

19. Request for Proposal Number TSC/TMP-0134-WB, U.S. Department of Transportation, Transportation Systems Center, Cambridge, Massachusetts, dated March 23, 1973.

20. Leasure, W.A. Jr., et al, Interior/Exterior Noise Levels of Over-the-Road Trucks: Report of Tests, NBS Technical Note 737, National Bureau of Standards, Washington, D.C., September, 1972.

21. Close, William H.; Clarke, Robert M., Truck Noise II, Interior and Exterior A-Weighted Sound Levels of Typical Highway Trucks, Report OST/TST-72-2 July 1972, U.S. Department of Transportation, Washington, D.C.

22. Motor Carrier Safety Regulations, Part 393, Parts and Accessories Necessary for Safe Operation Vehicle Interior Noise Levels. Final rule promulgated by the Bureau of Motor Carrier Safety establishing test procedures and enforcement levels for the safe interior noise level exposure of drivers relative to established hearing conservation criteria signed October 31, 1973, U.S. Department of Transportation, Washington, D.C.

23. Seiff, Henry E., Enforcement of Federal Motor Carrier Noise Regulation, Noise Con 73 Proceedings, pages 72-74, October 15-17, 1973. Institute of Noise Control Engineering, Washington, D.C.

24. Work Statement, Contract DOT-HS-241-420, "Vehicular Stresses Leading to Degradation of Driver Performance in Trucks, Buses and Passenger Cars," being performed by Human Factors Research, Inc.

25. Anon, Truck Noise I Peak A-weighted Sound Levels Due to Truck Tires, Report OST-ONA-71-9 September 1970, U.S. Department of Transportation, Washington, D.C.

26. Leasure, William A. Jr., et al, Truck Noise I Peak A-weighted Sound Levels Due to Truck Tires--Addendum, Report Number OST/TST-72-1 July 1972, U.S. Department of Transportation, Washington, D.C.

27. Leasure, W.A. Jr., et al, Truck Noise 1A: Noise Evaluation Tests of Military Truck Tires, Report DOT-TST-74-21, National Bureau of Standards, Washington, D.C., February 1974.

28. Close, William H., Truck Tire Noise: User Implications; Noisexpo 73 Proceedings, pages 67-72, September 11-13, 1973, Chicago, Illinois. Copies available from Noisexpo, Bay Village, Ohio.

29. Leasure, William A. Jr. and Bender, Eric K., Tire--Road Interaction Noise, paper to be published in the Journal of the Acoustical Society of America, prepared under the auspices of the ASA Coordinating Committee on Environmental Acoustics.

30. Leasure, W.A. Jr., Truck Tire Noise - Preliminary Results of a Field Measurement Program, Proceedings of the Purdue Noise Control Conference, Purdue University, West Lafayette, Indiana, July 1971, pages 41-48.

31. Leasure, W.A. Jr. and Bender, E.K., Tire Road Interaction Noise, Proceedings of Inter-Noise 73, Copenhagen, Denmark, August, 1973, pages 421-425.

32. Leasure, W.A. Jr., Automobile Tire Noise: A Review of the Open Literature, Proceedings of Noise - Con 73, Washington, D.C., October, 1973, pages 187-195.

33. Foster, Charles R., Statement: Before EPA Public Hearing on Interstate Motor Carrier Noise Regulations, March 21, 1974, Washington, D.C.

34. State of California Motor Vehicle Code Sections 27502 and 27503 pertaining to the establishment by California of noise standards for tire relative to the sale of such tires.

35. Reiter, William F. Jr., Investigation of Vibration in Truck Tire Noise Generation, August 1973, Publication of the Center for Acoustical Studies, Department of Mechanical and Aerospace Engineering, North Carolina State University.

36. Society of Automotive Engineers, Inc., Standard J366b entitled Exterior Sound Level for Heavy Trucks and Buses.

37. Society of Automotive Engineers, Inc., Recommended Practice J57, Sound Level for Highway Truck Tires.

38. Department of Transportation, Vehicle Noise Enforcement, Volume 1 of course curriculum material provided during DOT/CHP Training Program on Highway Noise Enforcement, May & June 1973, Sacramento, California.

39. U.S. Department of Transportation Vehicle Noise Enforcement, Volume 2 back-up information provided during training program in Sacramento including manufacturer muffler catalogs and other pertinent data.

40. Vehicle Noise Enforcement synchronous tape/slide package for administrators (carousel containing 122 slides, cassette tape and script).

41. Vehicle Noise Enforcement synchronous tape/slide package containing 140 slides in carousel plus cassette tape and script for instructors.

42. California Highway Patrol Final Report, Vehicle Noise Enforcement Training Program, August 15, 1973, prepared for U.S. Department of Transportation, Washington, D.C.

43. Anon, A Study of the Magnitude of Transportation Noise Generation and Potential Abatement, Volume IV Motor Vehicle/Highway Systems, U.S. Department of Transportation Report OST-ONA-71-1, Serendipity, Inc., November 1970.

44. Kwize, V.J., et al, Users Manual for the Prediction of Road Traffic Noise - Computer Program, U.S. Department of Transportation Report DOT-TSC-351-1, Bolt, Beranek and Newman, Inc., May 1972.

45. Wesler, J.E., Manual for Highway Noise Prediction, U.S. Department of Transportation Report DOT-TSC-FHWA-72-1, March 1972.

46. Wesler, J.E., Manual for Highway Noise Prediction (Short Version), U.S. Department of Transportation Report DOT-TSC-FHWA-72-2, March 1972.

47. Federal-Aid Highway Program Manual, Volume 7 Chapter 7 Section 3, Noise Standards and Procedures, U.S. Department of Transportation, Federal Highway Administration, Washington, D.C. (latest revision February 20, 1974. This section was formerly known as Program and Procedures Manual 90-2).

48. Anon, Fundamentals and Abatement of Highway Traffic Noise (Textbook and Training Course), U.S. Department of Transportation - Federal Highway Administration by Bolt, Beranek and Newman, Inc., 1973.

49. Rickley, E.J., et al, Wayside Noise and Vibration of High Speed Trains in the Northeast Corridor, U.S. Department of Transportation Report DOT-TSC-OST-73-18, September 1973.

50. Close, W.H. and Athinson, T., "Technical Basis for Motor Carrier and Railroad Noise Regulations", Sound and Vibration Magazine, October 1973, pages 28-33.

51. Rickley, E.J., et al, Noise Level Measurements of Railroads: Freight Yards and Wayside, U.S. Department of Transportation Report DOT-TSC-OST-73-46 (to be published).

5.2 DEPARTMENT OF DEFENSE

5.2.1 DOD/TACOM

References

52. Military Standard 1474, "Noise Limits for Army Material," March 1, 1973, U.S. Government Printing Office: 1973-714-917/1266.

53. TACOM Report No. 11314, "A Survey of Research in Noise Pollution Reduction Applicable to Military Vehicles."

54. TACOM Report No. 11710, "Test Results, U.S. Army Ground Vehicle Noise Studies, Yuma Proving Ground."

55. DOT Report No. TST 74-21, "Noise Evaluation Tests of Military Truck Tires."

56. TACOM Report No. 11761, "Military Vehicle Signature Collection and Classification Program, Phase II."

57. TACOM Report No. 11920, "Development of Noise Reduction Kits for a U.S. Army M813A1 5 Ton Truck."

58. TACOM Report No. 11949, "Prediction of Acoustic Detectability."

Bibliography

59. TACOM Report No. 10720, "Signature Characteristics of M656 Cargo Truck."

60. TACOM Report No. 10144(c), "Noise Reduction Test of XM 706."

61. TACOM Report No. 10012(c), "Noise Tests of M551."

62. TACOM Report No. 10089(c), "Noise Specification for the ARSV-XM800."

63. TACOM Report No. 9907(c), "Noise Reduction in Military Vehicles, Sound Pressure Levels and Distance to Inaudibility."

64. TACOM Report No. 9680(c), "Comparison of the Noise Emission of the M35A1, M543A2, and MAZ-200 Trucks."

65. TACOM Report No. 9618(c), "Noise Investigation of the MAZ-200."

66. TACOM Report No. 9467, "Noise Reduction in Military Vehicles."

5.2.2 DOD/MERDC

References

67. SAE Recommended Practice J919a, "Sound Level Measurements at the Operator Station for Agricultural and Construction Equipment (1971)."

68. "Final Report of Noise Reduction Study on Army Forklift," H.L. Blachford, Inc. Report No. 0473, AD786595.

69. Kamperman, G.W., "Techniques for Describing Operator Noise Exposure for Army Construction and Materials Handling Equipment."

70. SAE Recommended Practice J88, "Exterior Sound Level Measurement Procedure for Powered Mobile Construction Equipment."

71. Military Standard 1474A, "Noise Limits for Army Material," to be published March 1975, U.S. Naval Printing Office, Philadelphia, Pa.

72. Damotte, E.E., "Final Report Noise Level Study," Caterpillar Tractor Co. Report No. E70-220, September 1972.

73. Hopler, P.D. and Wehr, S.E., "Noise Reduction Program for U.S. Army Construction Equipment," SAE Paper No. 740714, National Combined Farm, Construction, Industrial Machinery and Power Plant Meetings, Milwaukee, Wisconsin, September 9-12, 1974.

74. Wehr, S.E., "Noise Exposure Monitoring on Operators of U.S. Army Construction and Materials Handling Equipment." To be presented at Inter-Noise 74, Washington, D.C., October 1974.

75. Kamperman, G.W., "Noise Control Methodology for Army Construction and Material Handling Equipment," to be presented to Commander, U.S. Army MERDC, STSFB-HM, Ft. Belvoir, Va. 22060, Attn. Samuel Wehr.

76. "Hydraulic System Noise Study," Oklahoma State University, Stillwater, December 1973, AD75776 (1972) and AD779466 (1973).

77. Maroney, G.E. and Elliott, L.R., "Hydraulic and Mechanical Factors Affecting Pump Airborne Noise Measurements," SAE Transactions, Vol. 82(1973), paper 730874.

78. "Environmental and Acoustical Test Program on Acoustic Materials," Dayton T. Brown, Inc., Report DTB03R73-0925.

Bibliography

79. Thien, G.E., "The Use of Specially Designed Covers and Shields to Reduce Diesel Engine Noise," SAE Transactions, Vol. 82(1973), paper 730244.

80. Baker, R.N., "Noise Control at the Operator's Ear of a Large Army Forklift Truck," to be presented at Inter-Noise 74, Washington, D.C., October 1974.

81. U.S. Army Human Engineering Laboratory, Standard HEL S-1-63C.

5.3 ENVIRONMENTAL PROTECTION AGENCY

References

82. Plotkin, Dr. K.J., "A Model for the Prediction of Highway Noise and Assessment of Strategies for its Abatement through Vehicle Noise Control," Wyle Research Report #WR74-5, EPA Contract #68-01-1860, to be published by EPA.

83. Sharp, Dr. B.H., "Roadside Measurements of Peak Pass-by Noise from Medium and Heavy Trucks," EPA Contract #68-01-1860, to be published by EPA.

84. EPA, "Background Document for Interstate Motor Carrier Noise Emissions Regulation," October, 1974, EPA-550-9-74-017. Copies can be obtained from the Office of Public Affairs, EPA, Rm. 329-C, Waterside Mall, 401 M St., S.W., Washington, D.C.,20460.

85. EPA, "Background Document/Environmental Explanation for the Proposed Interstate Rail Carrier Noise Emission Regulations," June 1974, EPA-550-9-74-005a. Copies can be obtained from the EPA Office of Public Affairs, Rm. 329-C, Waterside Mall, 401 M St., S.W., Washington, D.C., 20460.

86. Fath, J.M.; Blomquist, D.S.; Heinen, J.M.; and Tarica, M., "Measurements of Railroad Noise - Line Operations, Yard Boundaries, and Retarders," December, 1974, Joint EPA/NBS report NBSIR 74-488, EPA-550-9-74-007.

87. Warnix, James L. and Sharpe, Dr. B.H., "Cost Effectiveness Study of Major Sources of Noise, Vol. I, Medium and Heavy Trucks," Wyle Research Report #WR 74-5, EPA Contract #68-01-1860.

88. EPA, "Background Document for Proposed Medium and Heavy Truck Noise Regulation," October, 1974, EPA-550-9-74-018. Copies can be obtained from the Office of Public Affairs, EPA, 401 M St., S.W., Washington, D.C., 20460.

89. Leasure, W.A. Jr. and Quindry, T.L., "Methodology and Supporting Documentation for the Measurement of Noise from Medium and Heavy Trucks," NBSIR 74-517, June, 1974.

5.4 U.S. DEPARTMENT OF AGRICULTURE

5.4.1 Forest Service

References

90. Van Haverbeke, D.F. and Cook, D.I.,1972, "Green Mufflers," American Forests 78(11):28-31.

91. Van Haverbeke, D.F. and Cook, D.I.,1974, Part I, "Studies in Noise Pollution Reduction," American Nurseryman (June 1), 2 p.

92. Van Haverbeke, D.F. and Cook, D.I.,1974, Part II, "Suggested Plantings for Reducing Noise Pollution," American Nurseryman (June 15), 2 p.

93. Harrison, R.T., 1974, "Snowmobile Noise," Equipment Development and Test Report 7120-5, Forest Service, USDA, 48 p.

94. Harrison, R.T., 1974, "Sound Propagation and Annoyance Under Forest Conditions," Equipment Development and Test Report 7120-6, Forest Service, USDA, 35 p.

Bibliography

95. Cook, D.I. and Van Haverbeke, D.F, 1971, Trees and Shrubs for Noise Abatement, In: "Tree and Forests in an Urban Environment," University of Massachusetts, Amherst, Massachusetts.

96. Ibid, "The Role of Trees and Shrubs in Noise Abatement," Proceedings, The Role of Trees in the South's Urban Environment, University of Georgia, Athens, Georgia.

97. Grantham, J.B., 1971, "Airborne-Noise Control in Lightweight Floor Ceiling Systems," Sound and Vibration 5(6):12-16.

98. Heebink, T.B. and Grantham, J.B., 1971, "Field Laboratory STC Ratings of Wood-Framed Partitions," Sound and Vibration 5(10).

99. Anderson, L.O., et al, 1971, "Construction Guides for Exposed Wood Decks," Pacific Northwest, Forest Service, Miscellaneous Publication.

100. Leonard, R.E., 1971, "Effect of Trees and Forests in Noise Abatement," Trees and Forests in an Urbanizing Environment, University of Massachusetts Symposium Proceedings, pp. 35-38. (NE).

101. Leonard, R.E. and Herrington, L.P., 1971, "Noise Abatement in a Pine Plantation," USDA Forest Service Research Note NE-140,6 p.(NE).

5.4.2 Cooperative State Research Service

Bibliography

102. Hanson, J.E.; Sjoflot, L. and Suggs, C.W., 1970, "Matching the Farm Machine of the Operator's Capabilities and Limitations," Implement and Tractor 85(18):10-13.

103. Aylor, D.E., 1972, "Noise Reduction by Vegetation and Ground," J. Acoust. Soc. Amer., 51:197-205.

104. Ibid, 1972, "Sound Transmission Through Vegetation in Relation to Leaf Area Density, Leaf Width, and Breadth of Canopy," J. Acoust. Soc. Amer., 51:411-414.

105. Ibid, 1972, "Muffling Noise with Soil, Plants," Grounds Maintenance, 7(8):20-22.

6. APPENDICES

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APPENDIX A
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APPENDIX B

INFORMATION REQUESTED BY

EPA ON THE FEDERAL NOISE

RD&D PROGRAMS AND PROJECTS

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INSTRUCTIONS

The objectives of this information-gathering document is to assemble the data necessary to describe the over-all efforts within the Federal Government dealing with noise research, development and demonstration programs. The results will be used as a portion of the EPA report to the President and Congress on the status of Federal noise programs and to aid in coordination of Federal noise research efforts within Government agencies. The process is dynamic requiring that the data base be updated periodically to reflect changes in efforts, emphasis, expenditure of funds or completion of programs or projects.

The information requested on noise related programs and projects deal with the following areas:

- Program (Project) description.
- Technical goals and achievements.
- Financial and manpower resources devoted and required.
- Facilities used or required, and
- Key personnel.

The enclosed questionnaire is designed to reflect, as clearly as possible, the type of information required, but is not intended as a rigid format, hence, any agency forms that will furnish the required information easier than the questionnaire should be used by all means. If the questionnaire is used, notice should be made that:

1. Additional sheets may be used, and are encouraged, to furnish more details if the space provided is not adequate.

2. There is always a risk of not supplying enough information for the desired visibility of any program (project), but there is no risk of giving too lengthy information since this can easily be adapted to the overall report intensity or detail.

3. If the questionnaire forms miss entire aspects of program information, it is encouraged, in fact necessary, that you add these aspects under additional proper titles.

4. If your agency has a documented (or computer-stored) plan-program-project outlay with the required information it is strongly urged that it be included in the response.

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5. The program (project) information supplied should reflect actual FY 73 funding, allocated FY 74 and projections for FY 75 and later years.

6. For programs (projects) in which noise is only a part or a consideration it is requested that information should be given on:

   A. Program (project) specifics as outlined in the questionnaire.
   B. Additional statement on the relationship of the noise-related effort to the over-all scope of the program (project).

7. Finally, for any desired clarification of questions on this document, please call Dr. Eugene E. Berkau of the EPA at 202-755-0449.

The response to this questionnaire is requested by April 19, 1974.

Definitions in Responding
to the Form Titled

"FEDERAL NOISE RD & D PROGRAM SUMMARY"

Item	Remarks
1. Program Title	The formal agency title of record
2. Agency Program Number	The formal number of record; if programs are not numbered, write 'none'.
3. Agency or Department	Parent organization (e.g., DOT, DHEW).
4. Interagency Agreements in Effect	Identify other agencies or departments participating in the program and a brief description of their tasks.
5. Subdivision Directing Work	Organizational element where program responsibility exists (NIOSH/Physical Agent Branch) Name of Head.
6. Other Key Personnel	Additional leading personnel involved in administrative or technical management of overall program.
7. Principal Contractors	Identify contractors doing work for agency at the program (not the project) level.
8. Technical Program Goals	Those considered environmental goals, like quieting a specific machine by 10dB, or improving the reliability and sensitivity of needed instrumentation systems.
9. Method of Approach	Plans or Methodology for achieving program objectives.
10. Problem Areas	Identified technical, funding, and/or facilities problems.
11. Total Resource Allocation	
• Funding	The level of program funding devoted to noise RD&D distributed with time.

Item	Remarks
• Man-Years	The level of program manpower resources devoted to noise RD&D distributed with time.
12. Component Projects	A list of descriptive titles of those noise related projects within this program.
13. Schedules and Milestones	Show the current schedule and milestones; the "revised" column is for future use.
14. Principal Accomplishments	State achievements accomplished or within reach.
15. Program Reports, etc.	Confine this to those stemming from the overall program rather than the individual project. Include proceedings of symposia and conferences and papers in the professional literature as well as project reports and documents.

Note: A Federal noise RD&D program includes each program in which noise is a significant (one or more projects), identifiable program element.

Environmental Protection Agency
Office of Research and Development
FEDERAL NOISE RD&D PROGRAM SUMMARY

LEAD AGENCY

Agency or Department

Subdivision Directing Program/Head's Name, Title and Address

Name, Title, Address of Program Manager

Names and Titles of Other Key Program Personnel

Cooperating Agency or Department and Subdivision (if any)

Program Contractor or Grantee (if any)

Program Title	Agency Program Number
Authority (e.g., Public Laws, Agency/ Department Directives, etc.)	Date This Form is Filled

Date of Program Start	Scheduled Date of Program Completion.

Check appropriate classification(s) of program

☐ Research ☐ Development ☐ Demonstration

☐ Operations Research and/or Economic Benefit ☐ Other (Describe)

Program General Objectives

Program Specific Goals:

Planned Approach: (Attach additional sheets if necessary)

Problem Areas:

Total Resource Allocation	Fiscal Year	Cumulative Through FY 72	Actual FY 73	Allocated FY 74	Projected FY 75	FY 76	FY 77	FY 78	FY 79
	Funding $Thousand								
	Man-Years								

Program Schedules and Milestones (Detailed schedules and milestones may also be cited and appended to this response.)	Status		
Milestone	Scheduled Completion Date	Date Completed	or Revised Date

Agency/Project No.	Component Projects Descriptive/Project Title	Project Manager

Principal Accomplishments to Date (Include accomplishments relative to program goals or attained from combined project achievements)

Program Reports, Documents and Papers Published to Date: (List items attributed to the program. Complete bibliographic reference is desired/author, title, date, agency, document.)

APPENDIX C

GLOSSARY OF ACRONYMS

I. Federal Departments and Agencies

AMC - Army Materiel Command

BMCS - Bureau of Motor Carrier Safety/DOT

BuM - Bureau of Mines/DOI

CSRS - Cooperative State Research Service/USDA

DOC - Department of Commerce

DOD - Department of Defense

DOI - Department of Interior

DOL - Department of Labor

DOT - Department of Transportation

EPA - Environmental Protection Agency

FHWA - Federal Highway Administration/DOT

HEW - Department of Health, Education, and Welfare

HUD - Department of Housing and Urban Development

MERDC - U.S. Army Mobility Equipment Research and Development Center/DOD

NADC - Naval Air Development Center/DOD

NASA - National Aeronautics and Space Administration

NBS - National Bureau of Standards/DOC

NIEHS - National Institute for Environmental Health Sciences/HEW

NINDS - National Institute of Neurological Diseases and Stroke/HEW

NIOSH - National Institute for Occupational Safety and Health/HEW

NSF - National Science Foundation

ONAC - Office of Noise Abatement and Control/EPA

ORD - Office of Research and Development/EPA

OSHA - Occupational Safety and Health Administration/DOL

OVSR - Office of Vehicle Systems Research/NBS

RADC - Air Force Rome Air Development Center/DOD

TACOM - U.S. Army Tank Automotive Command/DOD

TECOM - U.S. Army Test and Evaluation Command/DOD

TSC - Transportation Systems Center/DOT

UMTA - Urban Mass Transportation Administration/DOT

USDA - U.S. Department of Agriculture

WES - Army Corp of Engineer Waterway Experiment Station/DOD

II. Trade Associations

AAR - Association of American Railroads

ASHO - Association of State Highway Officials

HRB - Highway Research Board/OSHO

MVMA - Motor Vehicle Manufacturers Association

NFPA - National Fluid Power Association

SAE - Society of Automotive Engineers

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Table B-1 SUMMARY SURFACE VEHICLE NOISE RESEARCH CONDUCTED BY NBS

Funding Agency	Title	Objectives	Fiscal Year Funding ($1,000) Prior to 1973	1973	1974	1975(est)
DOT	Truck Tire Noise Studies (includes passenger car tire noise, interior/exterior sound levels from over-the-road trucks, and feasibility of an acoustical grading system for tires).	To provide a scientific basis for designing quieter tires.	468	100	100	200
DOD	Noise evaluation tests of military truck tires.	To develop a data base on tire noise levels of selected military and commercial truck tires.			20	
EPA	Train Noise Study	To develop a data base on railroad noise emission.		25		
	Methodology for the measurement of noise from trucks.	Develop appropriate measurement methodology for use by EPA in the regulation of new trucks.			10	

NBS RESEARCH ON SURFACE TRANSPORTATION NOISE

NBS FUNDING: No current programs.

OTHER AGENCY FUNDING:

1a. Sponsoring Agency: U.S. Environmental Protection Agency/
Office of Noise Abatement and Control

Objectives: Develop appropriate measurement methodologies as technical support to the EPA in their implementation of the Noise Control Act of 1972, and, where necessary, conduct research to provide EPA with a defensible posture as regards to measurement methodology.

Approach: Establish and conduct meetings with an ad-hoc task force of experts (acousticians, manufacturers and users) in order to develop the rationale and necessary input for the measurement methodology for medium and heavy trucks. Conduct field measurements to characterize rail line and yard operations and retarder noise.

Future Plans: Conduct work where necessary and as requested by the U.S. Environmental Protection Agency.

Accomplishments: Completed the field measurement portion of the rail yard and line noise characterization study. Assembled and met with task forces in the area of interior rapid rail transit noise and construction noise -- especially crawler and wheeled tractors -- for the purpose of developing the rationale and inputs for an appropriate measurement methodology. A preliminary draft measurement methodology resulted from each of the meetings. Assembled and met with task force in the area of medium and heavy trucks. Developed and appropriate measurement methodology and supporting documentation for medium and heavy trucks.

Publications:

Fath, J. M., Blomquist, D. S., Heinen, J. M., and Tarica, M., "Measurements of Railroad Noise - Line Operation, Yard Boundaries, and Retarders", December, 1974, Joint EPA/NBS report NBS 74-488, EPA 550/9-74-007.

Leasure, W. A., Jr., and Quindry, T. L., "Methodology and Supporting Documentation for Measurement of Noise from Medium and Heavy Trucks", NBSIR 74-517, June, 1974.

Allocations:	FY-73	FY 74	FY 75(est)	FY 76(est)
k$:	23	12	-	-
Man-Years:	0.6	0.3	-	-

1b. Sponsoring Agency: Office of Noise Control, U.S. Department of Transportation

Objectives: Identify and quantify the physical parameters which affect the noise generated by surface transportation, especially trucks and truck tires, and develop appropriate information bases and standardized testing procedures which may lead to highway noise reduction criteria, standards, and regulations.

Approach: (1) Expand the existing data base on truck tire noise to include both passenger car and military truck tires. (2) Evaluate the spectral and directional characteristics of truck tires and of their relationship to tire-noise generation mechanisms. (3) Establish the effect of surface roughness on generated noise levels by correlation studies of surface texture (as characterized by profile spectral analysis) with passby noise levels for tires. (4) Prepare a report on tire noise measurement methodology which will serve the State of California as the basis for their regulations on allowable noise levels permissible for truck and passenger car tires.

Future Plans: Conduct work as necessary and where requested by the U.S. Department of Transportation.

Accomplishments: (1) Complete (contract) work on the characterization of pavement macrotexture by profile spectral analysis, (2) completed preliminary measurements and analysis of automobile tire noise, (3) complete narrow band analysis and plot generation needed for the reports on appropriate measurement methodology for tire certification testing and the spectral and directionality characteristics of truck tire noise which will be published, (4) completed the data acquisition portion of a truck tire noise versus pavement surface study, (5) developed an empirical model for the prediction of in-service tire noise levels for over-the-

road vehicles based on A-weighted sound level versus time (or distance) data for a 50 mph (80 kmh) coastby certification test utilizing a single chassis vehicle, (6) completed studies of military truck tire noise and automobile tire pavement interaction, and (7) initiated reports on expanded data base for truck tire noise and on measurement methodology for tire certification.

Publications:

Leasure, W. A. Jr., et. al., Truck Noise I Peak A-Weighted Sound Levels Due to Truck Tires - Addendum, Report Number OST/TST-72-1, July 1972, U.S. Department of Transportation, Washington, D.C.

Corley, D. M., "Test of a Proposed Method for Vehicle Noise Measurement" Proceedings of Noise-Con 73, Washington, D.C., 230-235 (Oct. 15-17, 1973).

Leasure, W. A., Jr., "Automobile Tire Noise: A Review of the Open Literature", Proceedings of Noise-Con 73, Washington, D.C., 187-195 (Oct. 15-17, 1973).

Leasure, W. A., Jr., and Mathews, D. E., "Pecos Truck Tire Noise Study: A Summary of Results", NBSIR 74-446, National Bureau of Standards, Washington, D.C. (January 1974).

Leasure, W. A., Jr., Mathews, D. E., and Rinkinen, W. J., "Noise Evaluation Tests of Military Truck Tires", submitted for publication as a Department of Transportation report.

Allocations:	FY 73	FY 74	FY 75(est)	FY 76(est)
k$:	100	100	-	-
Man-Years:	2.0	2.0	-	-